Description of the upper portion of the drill-core from Finngrundet in the South Bothnian Bay

TORSTEN E. TJERNVIK and JAN V. JOHANSSON

Tjernvik, T. E. and Johansson, J. V. 1980 01 15. Description of the upper portion of the drill-core from Finngrundet in the South Bothnian Bay. *Bulletin of the Geological Institutions of the University of Uppsala,* N. S., Vol 8, pp. 173—204. Uppsala. ISSN 0302—2749.

The biostratigraphy of a core from Finngrundet in the South Bothnian Bay (cf. Thorslund, this volume) is presented here. The The penetrated Ordovician limestone strata, overlying the *Dictyonema-Obolus* beds, have been examined by Tjernvik and Johansson. A section has been drawn and the rather poor fossil fauna investigated. Tjernvik has worked through the lower limestones, starting with those belonging to the Zone of *Megistaspis (Ekeraspis) armata*, and finishing with the Zone of *Megistaspis (Megistaspis) limbata.* Johansson has examined the two uppermost zones, that is, those of *Asaphus expansus* and of *A. "raniceps"*. For the purpose of drawing a parallel with the core, Tjernvik has enumerated many of the zonal fossils which have been found in the mainland of Sweden. They are often insufficiently known.

Torsten E. Tjernvik, Ånäsvägen 13 B, S-711 00 Lindesberg, Sweden; Jan V. Johansson, Knällinge, S-690 72 Sköllersta, Sweden. September 6th, 1979.

Contents

The Latorp and Lanna-Volkhov Stages

By T. E. Tjernvik

Introduction and Acknowledgements

I have taken on the task to give a biostratigraphical description of that part of the Finngrundet core which includes the limestone strata belonging to the Latorp and the Lanna-Volkhov Stages of the Lower Ordovicion. This I have done with some hesitation. The fossils encountered are few, and as usual in cores with a relatively small diameter, have often been damaged by the coring equipment. In addition, the greater part of the red limestone penetrated is very clayey which has led to an unfortunate corrosion of the exposed surfaces of the fossils. This fact has obstructed the identification and satisfactory illustration of many specimens. So has, for instance, the destruction of small but important details in the exoskeletons of the trilobite genus *Nileus* often made it impossible to recognize its species and subspecies. This genus, with its conspicuous and complicated evolutionary trends, has furnished a number of very good index fossils for the corresponding, hard, pure limestones on the mainland of South Central Sweden.

My paper "On the Early Ordovician of Sweden" (Tjernvik, 1956) is now out of date, and in some respects, inaccurate. After its publication, however, I have used time and labour on field work in various provinces of the country, all in the hope of being able to make a much needed revision of my description of these Ordovician strata and their faunas. It has so far given but one result: My subdivision of the Tremadocian in Sweden, 1958, has at last been accepted by O. M. B. Bulman and A. W. A. Rushton (1973).

The present revision includes the Hunneberg and Billingen Substages, which compose the Latorp Stage, and concern, *i. a.*, the relationship of their faunas to that of the underlying Upper Tremadocian, as well as to some later faunas. Yet, the main object of my research over many years has been the limestone strata which succeed the Latorp Stage. They were called the *Limbata* Limestone by J. C. Moberg in 1890, and the Volkhov Stage or the Volkhovian by V. Jaanusson in 1960. Here the denomination Lanna-Volkhov Stage will be used, because the more or less contemporaneous Scandinavian strata in question can not be correlated unquestionably with the Volkhovian of the Eastern Baltic region.

It is a deplorable fact that many of the old and, from a scientific point of view, very valuable Swedish quarries have been abandoned since the middle of the 1950's. Some have been filled, at least partly, with water. The lowest and most interesting Ordovician beds at Stenbrottet, described in may paper of 1956, have been covered with earth and large boulders during the reconstruction of a highway. Others are used as waste-tips by the local authorities. One of the best remaining sections through the limestone with *Asaphus expansus* at Västanå in the vicinity of the old Husbyfjöl, has lately become a site for the burning of rubbish. It was once one of the most famous Ordovician localities of Östergötland, and has delivered exquisite and whole specimens of trilobites for more than 150 years.

Jan V. Johansson has, however, discovered several new sections in various parts of Sweden. These can take the place of those which have been lost during the last decennia. His careful and systematic examinations and his collecting of a great multitude of fossils have added considerably to the knowledge of the Cambrian and Ordovician faunas. A few of his discoveries will be mentioned in the following.

I want to express my most sincere thanks to Professor Emeritus Per Thorslund who has supported me greatly at my work of the last years. I am also indepted to Professor Richard A. Reyment of Uppsala, and Professor Gerhard Regnéll of Lund for their help in many ways. Professor Reyment has made every effort to facilitate my research at his Institute. My discussions on the fossils with Dr. R. A. Fortey of the British Museum have been of the greatest value to me. I am grateful to the technical staff of the Palaeontological Institute of Uppsala for their patient and skilfull assistance. The fossil material, from the mainland as well as the core, was prepared by Mrs. M. Lindell and Mrs. B. Jansson. The photographs were taken by Mr. G. Andersson and the late Mr. N. Hjorth. The drawings were made by Mrs. D. Engström. Mrs. E. Eklind made a fair copy of a great part of the manuscript. Inappropriate details in regard of the text, and the English language were kindly corrected by Professor R. A. Reyment.

A renewed scrutiny of the Lanna section and comparative examinations of outcrops in Skåne, Öland, Östergötland, Västergötland, Dalarna, and southern Norway, as well as the succeeding treatment of the fossils, have been made possible by generous grants from Statens Naturvetenskapliga Forskningsråd (Swedish Natural Science Research Council). An additional grant has been given for the investigation of the drill-core, from the South Bothnian Bay and described, to some extent, in this paper.

CORRELATION TABLE

Great Britain	Baltoscandian limestone sequence Jaanusson (1960)		Sweden		
	Stage	Substage	Shelly facies	Graptolite facies	Finngrundet Zones etc.
Llanvirn	Kundan	Valastean	?	*Didymograptus "bifidus"*	*Asaphus "raniceps"*
		Hunderumian		*Didymograptus hirundo* fauna	*Asaphus expansus*
Arenig	Volkhovian	Langevojan	Lanna-Volkhov Stage	*Isograptus gibberulus*	*Megistaspis (Megistaspis) limbata*
					Megistaspis (Megistaspis) simon
				Didymograptus hirundo Early form	*Megistaspis (Megistaspis) lata*
	Latorpian	Billingenian	Latorp Stage: b) Billingen Substage	*Phyllograptus angustifolius elongatus*	*Megistaspis (Varvaspis) estonica*
				Phyllograptus densus	*Megalaspides (M.) dalecarlicus*
				Didymograptus balticus	Transition Beds *Megistaspis (V.)* aff. *estonica*
?		Hunnebergian	a) Hunneberg Substage	*Tetragraptus phyllograptoides*	*Megistaspis (Varvaspis) planilimbata*
Hiatus				Earliest dichograptid fauna	*Megistaspis (Ekeraspis) armata*
			Upper Tremadocian	*Clonograptus heres?*	Hiatus
Tremadoc				*Dictyonema* Shale	*Obolus* Sandstone
					Dictyonema Shale
Cambrian					Hiatus
					Lower Cambrian

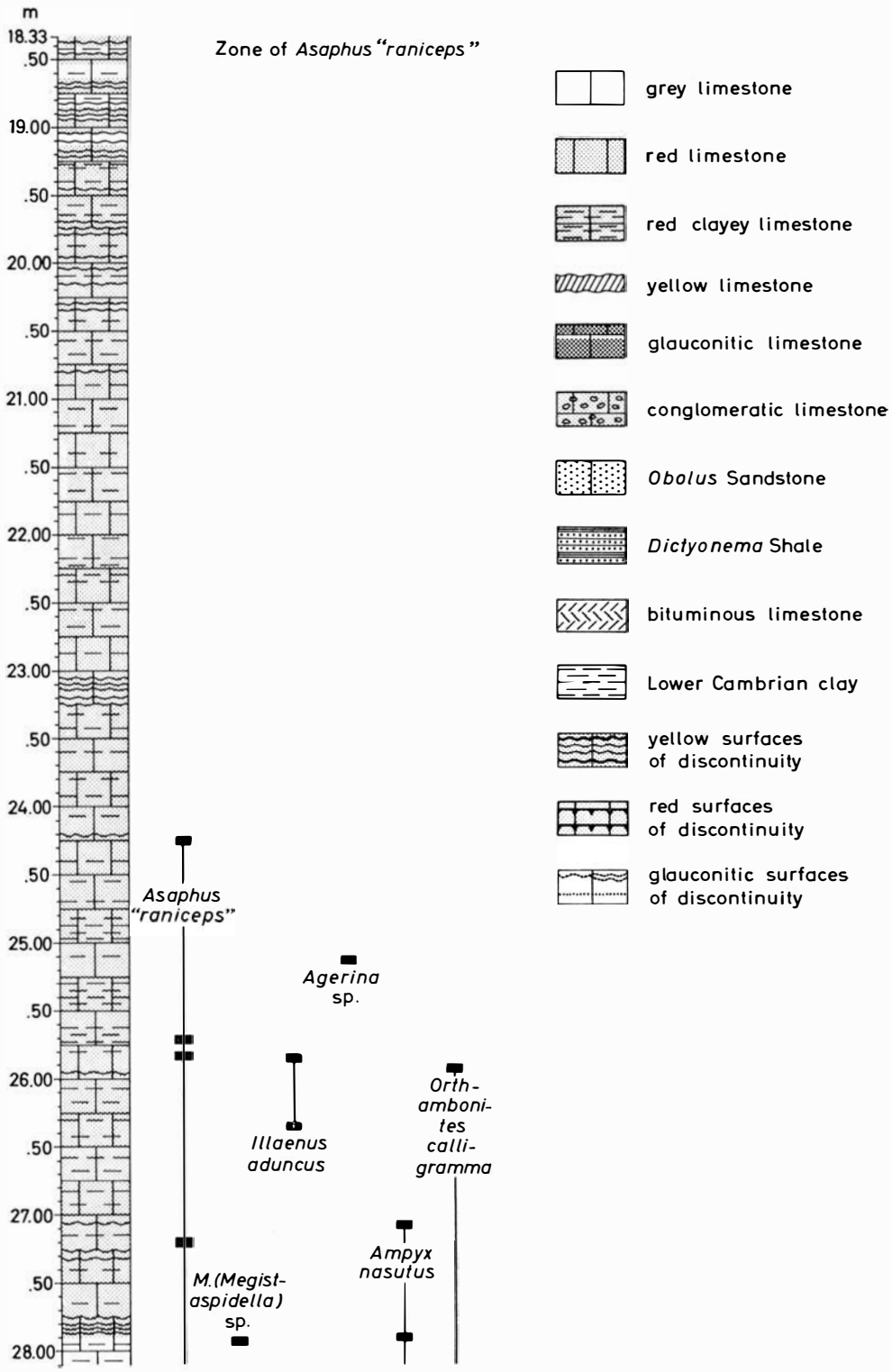


Fig. 1. Section through the Ordovician limestones penetrated by the Finngrundet (Östra banken) drill-core.

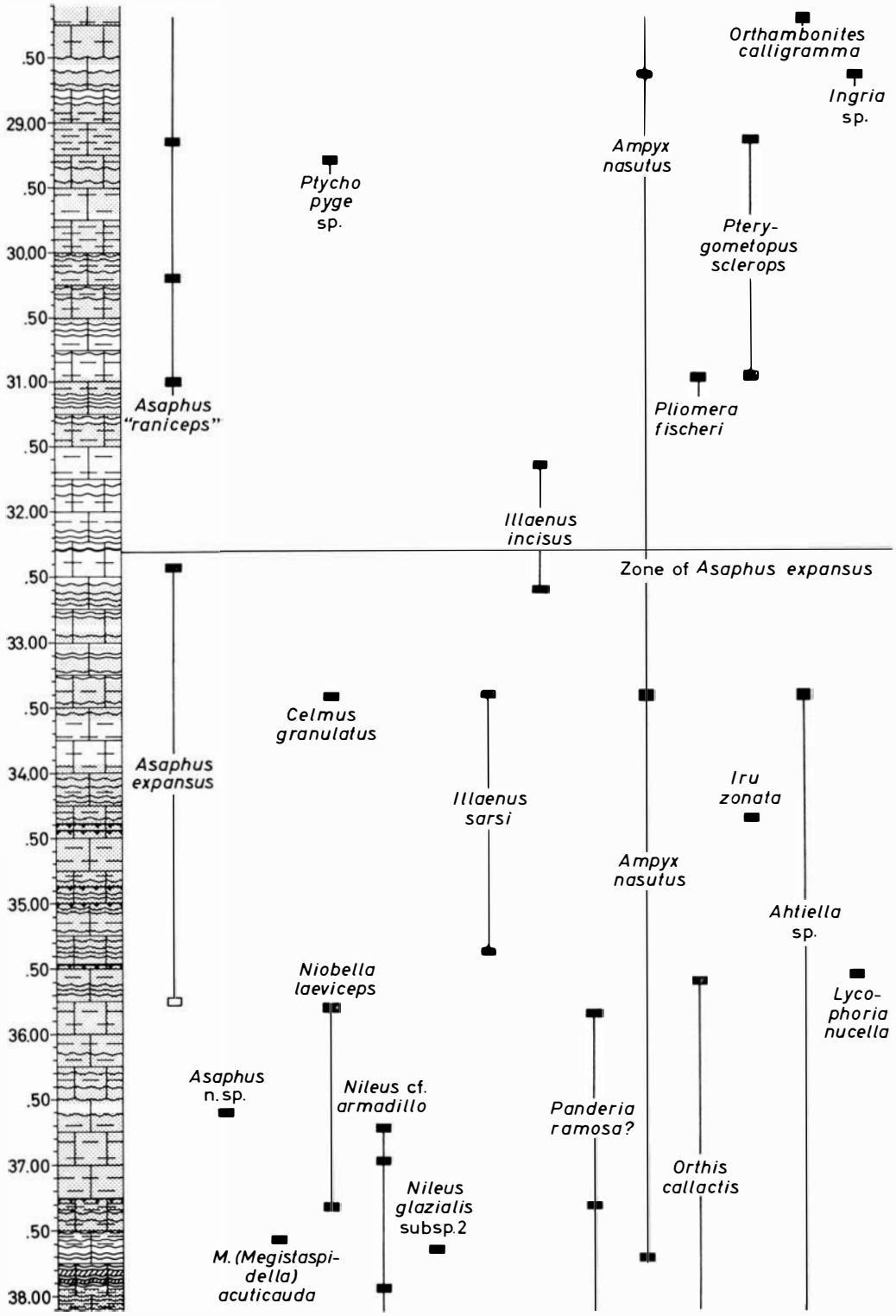


Fig. 2. The Finngrundet (Östra banken) drill-core (continued).

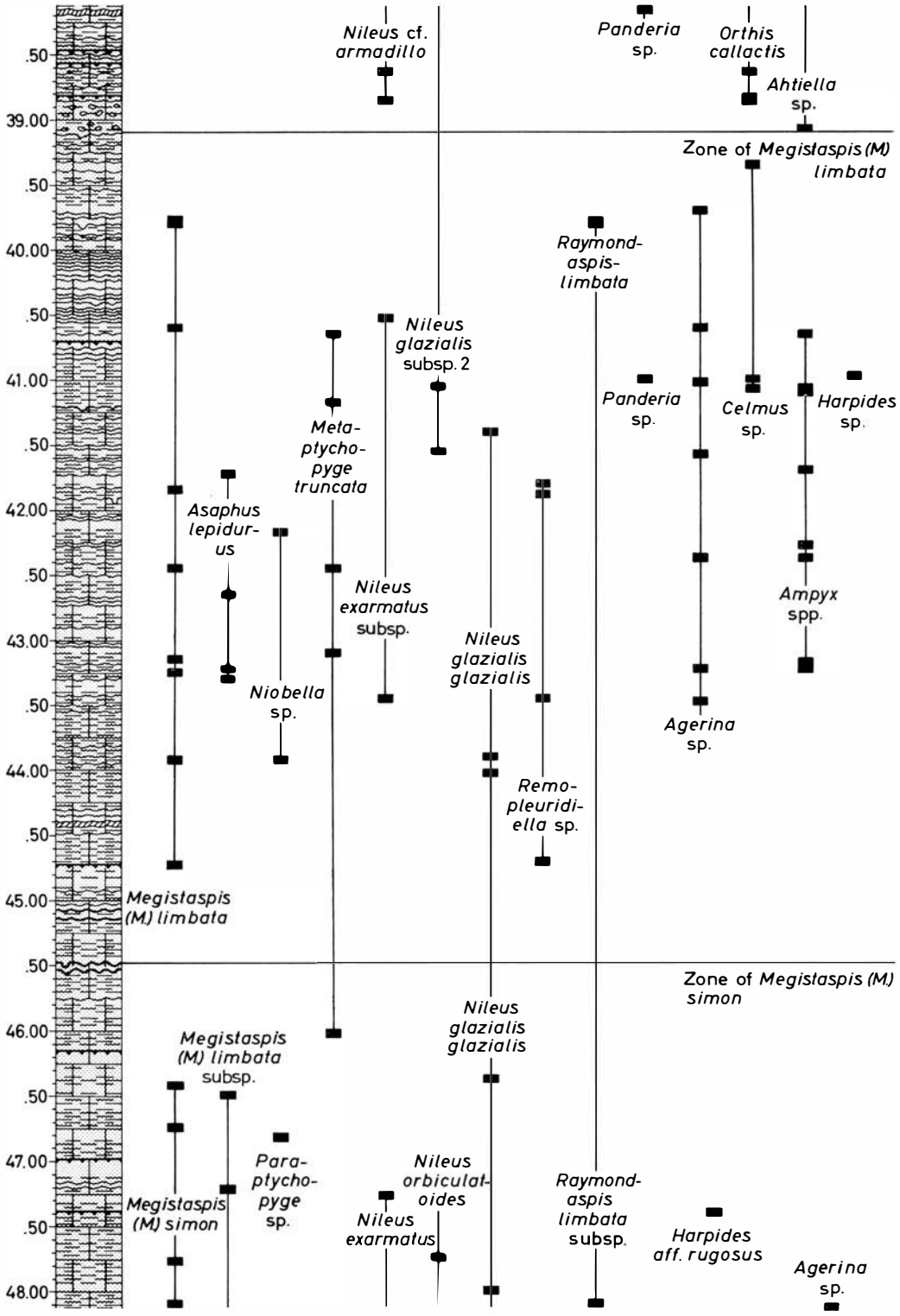


Fig. 3. The Finngrundet (Östra banken) drill-core (continued).

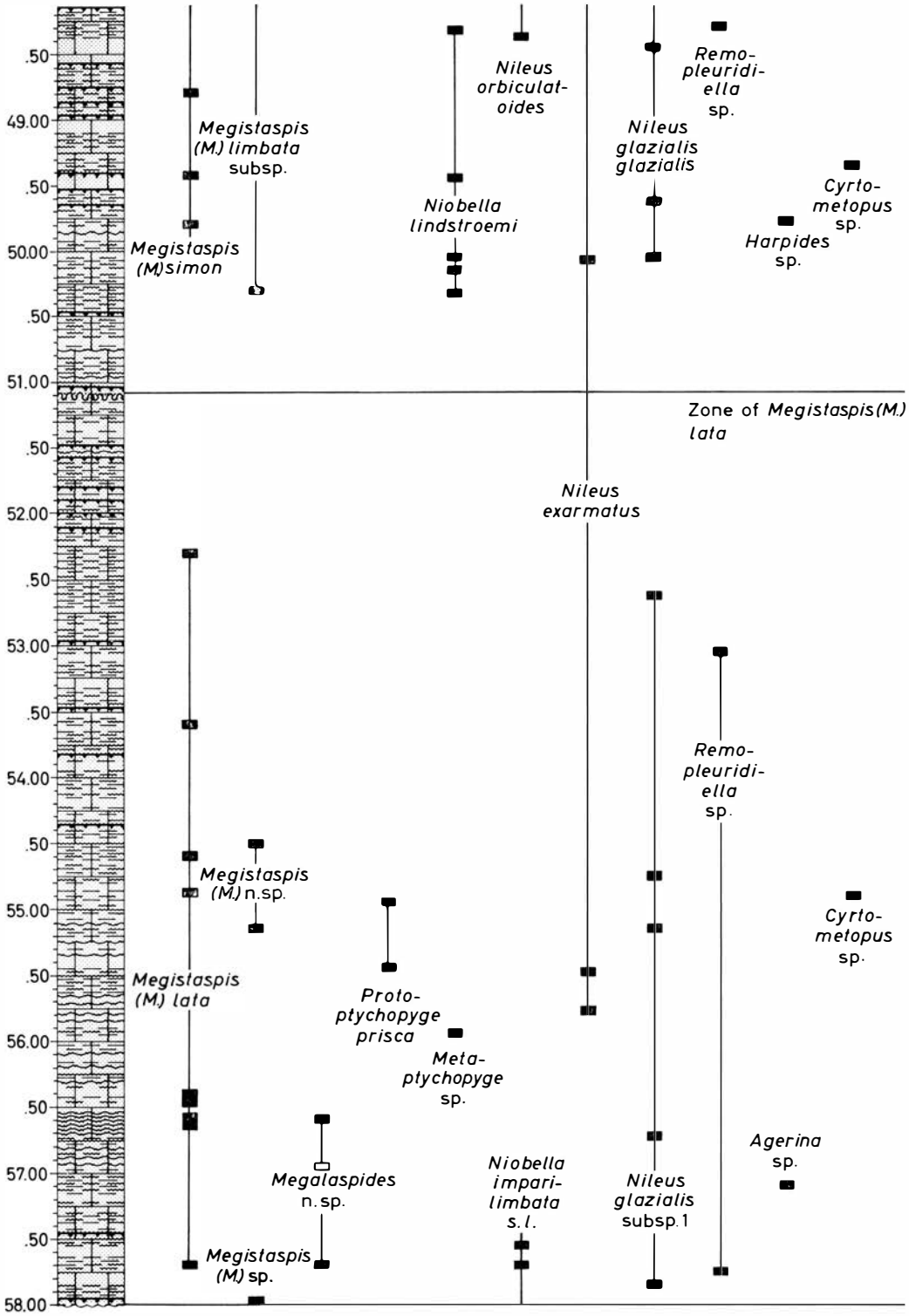


Fig. 4. The Finngrundet (Östra banken) drill-core (continued).

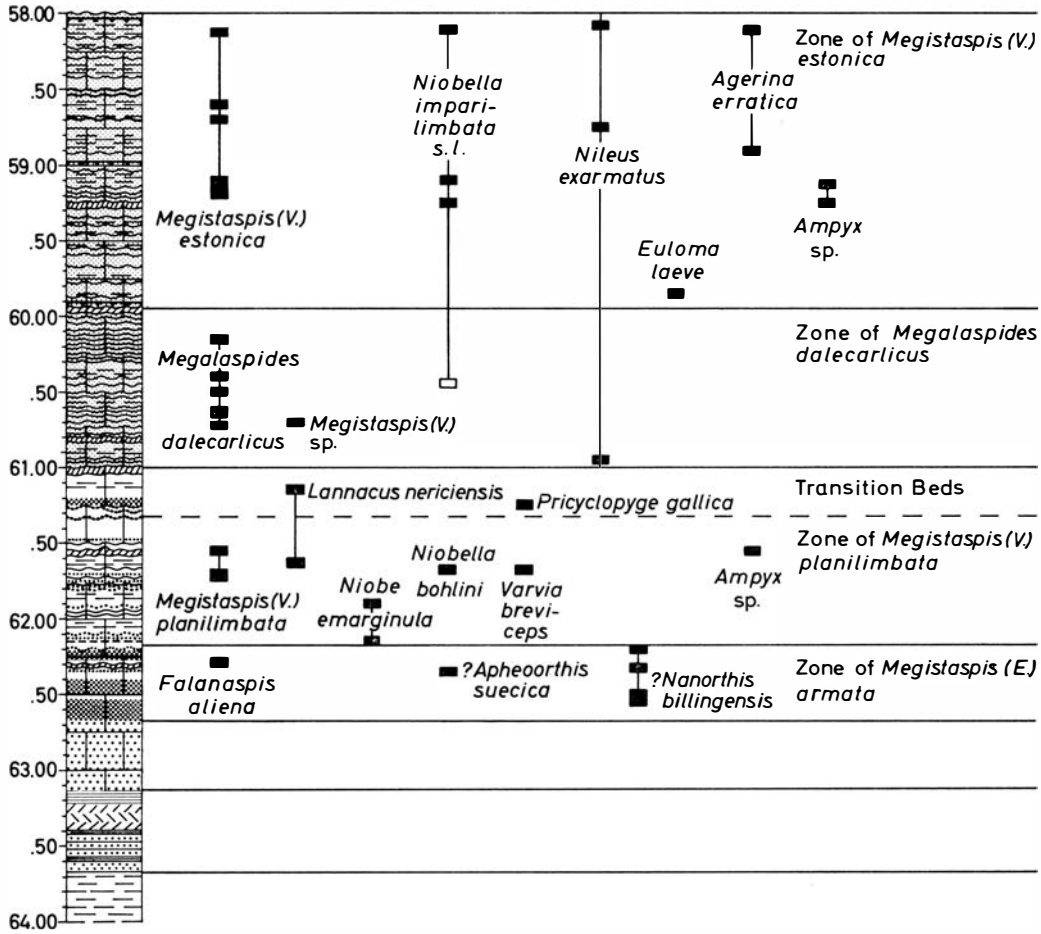


Fig. 5. The Finngrundet (Östra banken) drill-core (continued).

Latorp Stage

58,00—62,68 m = about 4,7 m thick

Assemblages and Variability

At the end of the description of every particular zone encountered in the core, there is a list of life forms occurring in the same subdivision of the mainland. In this connection, it ought to be mentioned that trilobite assemblage zones can not be precise biostratigraphic units. Genera and species pass occasionally the zonal boundaries without any morphological change. This is true of, for instance, the subgenera of *Megistaspis* and *Megalaspides*, as well as of the genera *Niobella*, *Nileus* and *Symphysurus*. According to the opinion and experience of many investigators, the assemblage zones are, however, very useful in stratigraphic correlation.

Many species show a strong variability. A *sensu lato* has been added to the names of several long-lived ones belonging to the above-mentioned genera and subgenera. Jan V. Johansson is studying this variability, and has gathered a large and well-documented material from various parts of Scandinavia.

Hunneberg Substage

61,32—62,68 m = about 1,35 m thick

This subdivision is characteristic of Sweden, and unique in its richness in old and peculiar fossils. Some genera and species are related to or identical

with Tremadocian ones. Others are early relations of later genera. They will be discussed at some length below. The substage comprises two zones which are poorly represented in the core:

Zone of *Megistaspis (Ekeraspis) armata*

62,17—62,68 m = about 0,5 m thick

It begins with a layer of glauconitiferous limestone, which is about 0,1 m thick, and contains only fragments of obolids. Its age is accordingly unknown, but may possibly be ascertained by its content of conodonts.

The overlying rock is light-grey, white or yellowish. It contains several portions of glauconitic limestone with well-rounded grains of quartz, the latter probably emanating from the underlying *Obolus* Sandstone. A very interesting fact is that Thorslund has encountered (at the level of 62,50 m) a thin layer of a light-grey bentonitic clayey matter. The upper boundary of the zone has been drawn at a couple of discontinuity surfaces, impregnated with glauconite, and running into one another. They are situated at the level of 62,17 m. The fauna is very poor, and consists only of the following species:

Trilobita:

Falanaspis aliena Tjernvik, a fragmentary genicranium, *Niobella* sp., hypostoma.

Brachiopoda:

Apheoorthis? suecica Tjernvik, a very good index fossil for the zone; *Nanorthis? billingensis* Tjernvik, and *Nanorthis?*, small sp.

On the mainland of Sweden, the fauna is much richer. It contains:

Trilobita:

Falanaspis aliena, *Geragnostus crassus* Tjernvik, *G. lepidus* Tjernvik, *Hunnebergia retusa* Tjernvik, *Lapidaria tenella* Tjernvik, *Megistaspis (Ekeraspis) armata* (Tjernvik), *Nileus limbatus* Brögger *s. l.*, *Niobe incerta* Tjernvik, *Niobella bohlini* Tjernvik *s. l.*, *Orometopus grypos* Tjernvik, *Platypeltoides serus* Tjernvik, *Saltaspis viator* Tjernvik, *Symphysurus angustatus* (Sars & Boeck) *s. l.*, and *Varvia falensis* Tjernvik.

Brachiopoda:

Apheoorthis? suecica, *Lamanskya splendens* Moberg & Segerberg, *Leiocardinia difformis* (Moberg & Segerberg), formerly identified by myself with "*Lycophoria laevis* Stolley"; *Nanorthis? billingensis*, and *Nanorthis?*, small sp.

Undescribed or unsufficiently known genera and species:

Apatokephalus sp., *Borogothus* aff. *stenorhachis* (Angelin), *Euloma* n. sp., *Harpides* cf. *rugosus* (Sars & Boeck), *Megistaspis* n. sp., pygidia with a very narrow, flattened border; *Parabolinella?* n. sp., *Shumardia?* sp., *Triarthrus?* n. sp., and other unknown forms.

Several new trilobite genera are of special interest. For instance, a good cranidium has been found which, according to Fortey (personal communication) seems to belong to an illaenid/scutellid "near the point of separation". There exist also fragments of the earliest odontopleurid, known to me. The occurrence of some of the above genera and species will be discussed in the following, after the description of the next zone.

Jan Johansson has discovered a new exposure of the *armata* zone at Gymninge in Närke. It is 0,4 m thick, and contains a rich trilobite fauna, divergent from that of Västergötland.

At the Hunneberg Mountain in Västergötland, trilobite-bearing limestones and portions of the Lower *Didymograptus* Shales intermingle in an interesting way. Recent research in the field has facilitated the correlation of a couple of trilobite and graptolite stratigraphical units, and has led to a revision of my old scheme of 1956 (cf. Table, p. 175 in this paper). The Hunneberg Substage is not, or poorly, represented in Great Britain, Estonia, and the Leningrad district. It is evident that the Zone of *Megistaspis (Ekeraspis) armata* at Hunneberg corresponds to a dark schale with a rich but very poorly known graptolite fauna. Erdtmann (1965) has studied this fauna at Hunneberg, and also in the city of Oslo. He stated in his paper of 1965, p. 496, that "the stratigraphical position of this horizon supports the proposition that the graptolite assemblage encountered contains the earliest dichograptid fauna ever reported from Europe".

This early graptolite fauna is currently being investigated by Miss Kristina Lindholm of Lund University.

Zone of *Megistaspis (Varvaspis) planilimbata*

61,32—62,17 m = 8,85 m thick

The limestone is greenish grey with few, or occasionally, numerous glauconite grains. It is in part clayey, and contains discontinuity surfaces covered with glauconite. In addition, several layers of bright yellow limestone occur. Their colour is certainly due to the presence of goethite, caused by oxidation. They are usually very thin, but may be 2 to 4 cm thick. Some of their upper borders

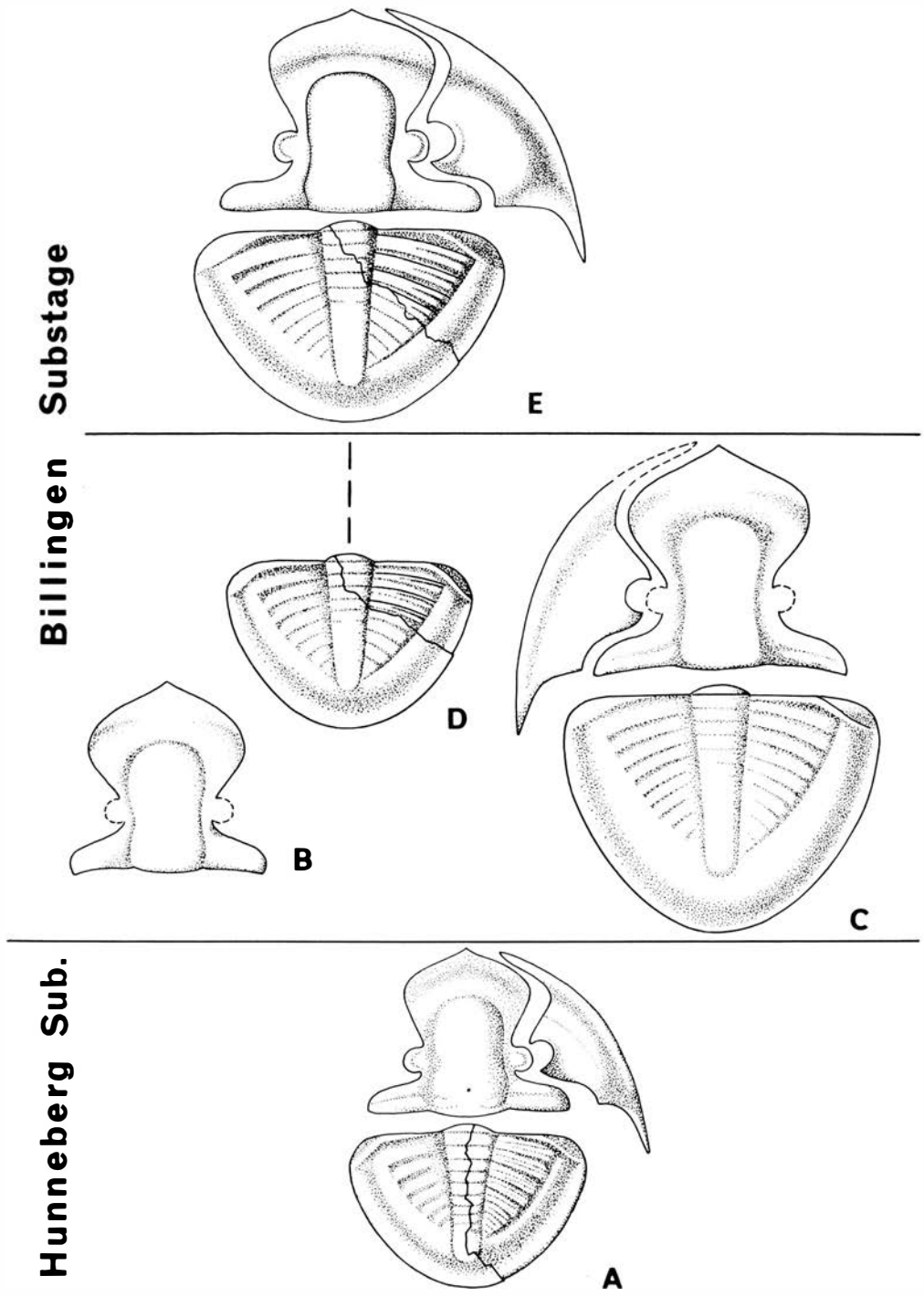


Fig. 6. Schematic drawings of some species belonging to *Megistaspis* (*Varvaspis*) n. subgenus. A: *M.* (*V.*) *planilimbata.* B: *M.* (*V.*) *norvegica.* C: *M.* (*V.*) *scutata.* D: *M.* (*V.*) aff. *estonica.* E: *M.* (*V.*) *estonica.*

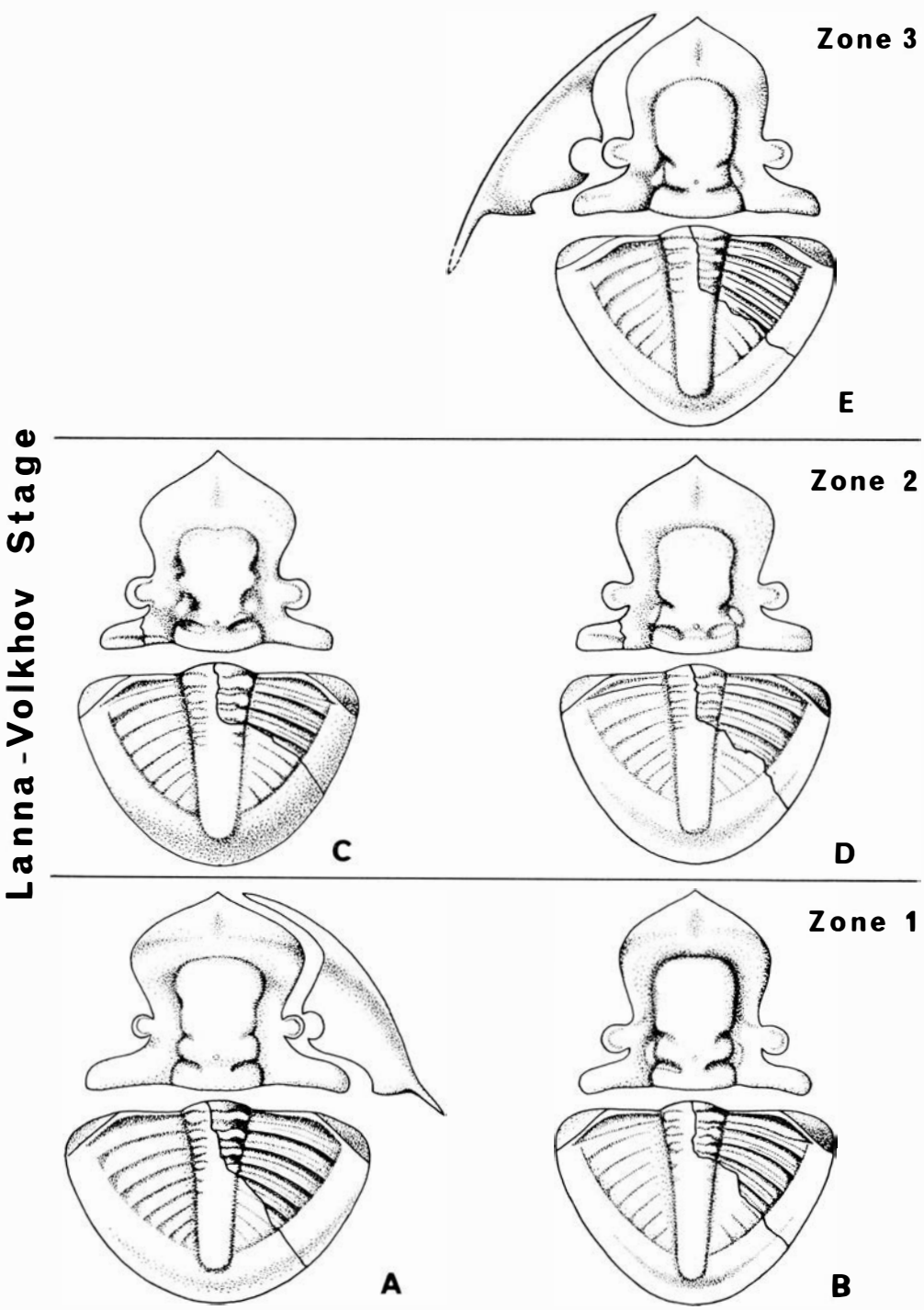


Fig. 7. Schematic drawings of some species and one subspecies belonging to *Megistaspis* (*Megistaspis*) Jaanusson 1956. A: *M.* (*M.*) *lata.* B: *M.* (*M.*) n. sp. no. 1. C: *M.* (*M.*) *simon* n. sp. D: *M.* (*M.*) *limbata* n. subsp. E: *M.* (*M.*) *limbata.*

are certainly identical with discontinuity surfaces. The upper boundary of the zone is drawn at a glauconitic level situated at 61,32 m.

Trilobita:

Only a few trilobites have been found in the core. They are:

Ampyx cf. *pater* Holm (in Tjernvik, 1956, pl. 11, fig. 15), *Megalaspides* (*Lannacus*) *nericiensis* Wiman, *Megistaspis* (*Varvaspis*) *planilimbata* (Angelin), *Niobe emarginula* Angelin, *Niobella bohlini*, and *Varvia breviceps* (Angelin).

The Swedish mainland fauna of the zone may be very rich and the majority of its species are known of old, even if several have formerly been unnamed or been given new names at their redescription. They are:

Ampyx? brevicauda Wiman, *Apatokephalus pecten* Wiman, *Borogothus stenorhachis*, *Geragnostus crassus*, *G. wimani* Tjernvik, *G.? explanatus* Tjernvik, *Gyrometopus lineatus* (Angelin), *Ischyrophyma insolita* (Tjernvik), *Lapidaria rugosa* Tjernvik, *Leiagnostus peltatus* Tjernvik, *Megalaspides* (*Lannacus*) *nericiensis*, *Megistaspis* (*Ekeraspis*) *heoides* (Brögger), at the base of the zone; *Megistaspis* (*Varvaspis*) *planilimbata, Nileus limbatus s.l.*, *Niobe emarginula*, *Niobella bohlini*, *Ottenbyaspis perseverans* (Tjernvik), *Protopliomerops actinurus* (Dalman), *Shumardia? nericensis* Wiman, *Symphysurus angustatus s.l.*, *Trinodus elliptifrons* Tjernvik, and *Varvia breviceps.*

Undescribed or insufficiently known trilobite species:

Ampyx cf. *pater*, *Borogothus* aff. *stenorhachis*, *Euloma* sp., *Falanaspis* n. sp., collected by Johansson from the basal beds at Hunneberg; *Gog* Fortey n. sp., *Harpides* cf. *rugosus*, *Illaenus?* sp., *Megistaspis* (*Varvaspis*), n. sp., *Megistaspis* aff. *ringsakerensis* (Skjeseth), an early form found by Johansson; *Miracybele* n. sp., cranidium; *Orometopus* sp., *Pricyclopyge gallica s.l.*, *Pytine* Fortey n. sp., *Raymondaspis* n. sp., collected by Johansson; *Remopleuridiella* sp. (Tjernvik, 1956, p. 203), *Selenoharpes* sp., *Triarthrus?* sp. (= *Parabolinella* sp. no. 2, Tjernvik, 1956, p. 201), and several other unknown genera and species, usually of small size.

Late Tremadocian trilobite fauna compared with Hunnebergian and later faunas

The Working Group on the Cambrian-Ordovician boundary has tried to draw an internationally accepted borderline between the two great systems. The stratigraphical position of the *Dictyonema* Shales is somewhat problematic, and will not be discussed here. The Upper Tremadocian, on the other hand, must without doubt be included within the Ordovician. The Hunneberg Substage seems to fill out the hiatus existing between the Tremadoc and Arenig of Great Britain, and its rich trilobite fauna is, to the best of my knowledge, missing in the early glauconitiferous strata of Estonia and the Leningrad region. In Norway, the limestones corresponding to the Hunneberg Substage are often replaced by graptolite shales. The trilobite fauna of the *planilimbata* zone is, however, fairly well developed, and was described by Skjeseth in 1952. The underlying *armata* zone, on the contrary, seems at present to be known only from Sweden.

The Middle and Upper Tremadocian zones of Sweden are those of *Platypeltoides incipiens* and *Apatokephalus serratus.* Several trilobite genera and species are restricted to these subdivisions, but some occur also in one or both zones of the Hunneberg Substage. The latter genera are: *Apatokephalus*, *Borogothus*, *Falanaspis*, *Lapidaria*, *Ottenbyaspis*, *Platypeltoides*, *Pricyclopyge*, *Saltaspis*, *Shumardia?* (*Conophrys?*), and *Varvia.* Several other genera reach higher, sometimes considerably higher levels. Some of these are, for instance: *Agerina*, *Euloma*, *Harpides*, *Niobe*, *Niobella*, and *Orometopus.*

Apatokephalus and *Borogothus* are well represented in the *serratus* zone and all the Hunneberg Substage. *Borogothus* enters also the Transition Beds at the base of the Billingen Substage.

Falanaspis aliena had only been known from the *armata* zone until a genicranium was reported by Henningsmoen (1959, p. 171) from the uppermost Tremadocian *Ceratopyge* Limestone (3aγ) at Vekkerø in Oslo. He remarks: "There seems to be no reason to describe it as a new form although it occurs in the zone below that of the Swedish specimens". Furthermore, a new species of *Falanaspis* has been encountered by Johansson in the basal layers of the *planilimbata* zone at Hunneberg. These Scandinavian forms are certainly related to *Falanaspis extensa* Fortey, from the middle Arenig Olenidsletta Member of Spitsbergen.

A librigena of *Lapidaria* sp. was collected from the *serratus* zone at Mossebo in Västergötland, and generously presented to me by Mr. P. Whit-

worth of Birmingham University in 1969. *Lapidaria tenella* occurs in the *armata* zone, and *L. rugosa* in the *planilimbata* zone.

The genus *Ottenbyaspis* was founded by Bruton (1968). Its earliest known species is *O. oriens* (Moberg & Segerberg) which is fairly frequent in the *serratus* zone. Only one other species of this genus, *O. perseverans*, has hitherto been secured. It occurs sparsely in the lower part of the *planilimbata* zone of Southern Sweden. The genus resembles *Panderia* Volborth, but any grading of *Ottenbyaspis* into *Panderia*, as discussed by Dean (1973, p. 322), is not easy to ascertain. *Panderia* is a considerably later genus, and turns up at first in the upper part of the zone of *Megistaspis* (*Megistaspis*) *lata*. No intermediate forms are known with any certainty.

Platypeltoides Pribyl is characteristic of the middle Tremadocian Zone of *Platypeltoides incipiens*, but is also known from the Hunnebergian *armata* zone. The cranidium of a species belonging to *Saltaspis* Harrington & Leanza has been collected from the *serratus* zone at Stenbrottet in Västergötland (cf. Tjernvik, 1956, p. 203, pl. 2, fig. 4) and *Saltaspis viator* has been found in the *armata* zone at several localities.

Varvia Tjernvik differs from the contemporaneous *Symphysurus angustatus s.l.*, in its librigenae being separated by a median suture. The genus disappears for good, with *Varvia breviceps*, in the middle of the *planilimbata* zone, after having brought forth good index fossils for the three zones of the uppermost Tremadocian and the Hunneberg Substage.

Two long-lived species from the same subdivisions are of importance. One is *Nileus limbatus* which is characterized by its narrow and rectangular glabella and its conspicuously wide and deeply concave pygidial border. It disappears at a level somewhat above the middle of the *planilimbata* zone. The other species is *Symphysurus angustatus* which abounds from the upper Tremadocian to the very top of the *planilimbata* zone, where it also disappears in a sudden way. The members of the two species are of different ages, but grade into each other so imperceptly that a subdivision into separate forms has hitherto not been possible to me. A *sensu lato* has, however, been added to their names. At the base of the Billingen Substage, they are replaced by two quite different species.

Forerunning forms of later, even much later genera, are rather typical of the Hunneberg Substage, a fact which may complicate the correlation of the Lower Ordovician faunas of Northern Europe, Spitsbergen, and Newfoundland.

Two of these interesting forms are the before mentioned illaenid/scutellid in the *armata* zone, and the genus *Gog* Fortey in the *planilimbata* zone. Pygidia of a species belonging to the latter are rarely met with in Southern Sweden. Farther to the north, in the province of Jämtland, they are more frequent. An incomplete pygidium from this province was illustrated by Fortey (1975, pl. 4, fig. 30). The large trilobite *Gog catillus* Fortey occurs in the same Arenig Member of Spitsbergen as *Falanaspis extensa*. According to Fortey, the genus *Gog* possesses features transitional between niobinid and ogyiocarinid trilobites. The pygidium is very similar to that of *Ogygiocaris* species. The cephalon, however, suggest affinities with *Niobe* species rather than with those of *Ogygiocaris*, and indicates that *Gog* schould be included within the Niobinae rather than the Ogygiocaridinae.

Billingen Substage

58,00—61,32 m = about 3,3 m thick

This substage is included within the Latorp Stage, because of its rich content of trilobite species belonging of the *planilimbata* group. These species have also been given the subgeneric name of *Megistaspis* (*Varvaspis*).

Transition Beds

61,00—61,32 m = about 0,3 m thick

In Tjernvik (1956, p. 138) I described briefly the *planilimbata* zone at Gymninge in Närke. I mentioned that the uppermost strata of this unit contain a divergent fauna. At the public defence of my doctor's dissertation of 1956, Professor Maurits Lindström pointed out that these topmost beds could hardly be included with the *planilimbata* zone. Later examinations have proved that he was right. He correlated (1957, p. 162) the strata in question with the Zone of *Didymograptus balticus*.

It is true that a few species from the underlying Hunneberg Substage still occur more or less frequently: *Megalaspides* (*Lannacus*) *nericiensis s.l.*, *Niobella bohlini s.l.*, and the latest known *Borogothus* sp., probably identical with *B. stenorhachis*. Furthermore, a small fragment of a pygidium, possibly belonging to *Niobe emarginula*, has been encountered. These survivors into the next substage are the cause of the denomination Transition Beds.

On the other hand, the rest of the trilobite fauna resembles that of the Billingen Substage. *Megistaspis* (*Varvaspis*) *planilimbata* has disappeared, and is replaced by the first representative

of an "*estonica* sequence" which ends with *M. (V.) estonica* (Tjernvik) at top of the substage. The members of the sequence show an evolution in the hypostoma, similar to that in *M. (V.) planilimbata.* In the earliest species of the new series, *M. (V.)* aff. *estonica*, characteristic of the Transition Beds, the posterior margin of the hypostoma is convex, while in the last one, *M. (V.) estonica*, it is concave (cf. Tjernvik, 1956, pl. 6, fig. 12. The hypostoma in pl. 6, fig. 13, does not belong to the species, certainly not even to the genus).

Symphysurus angustatus s. l., which abounds in the earlier strata, has also disappeared from this unit, as mentioned above, and has been replaced by a new species with a broad and almost quadratic glabella. Its sparse vertical distribution reaches the basal beds of the much later Zone of *Megistaspis (Megistaspis) limbata. Nileus limbatus s. l.* is exchanged for the first member of a *Nileus exarmatus* sequence which occurs abundantly in the succeeding zones. The glabella begins to taper forwardly and the wide and deeply concave pygidial border has now become a more or less narrow despression, parallel to the lateral and posterior margin. Furthermore, in *Nileus orbiculatus* Tjernvik one meets with the first outburst of the tendency in the genus to create quite convex pygidia.

The lower portion of the Transition Beds at Gyminge is a grey limestone which may be crowded with specimens of *Pricyclopyge gallica s. l.* Further genera and species are: *Ampyx? obtusus* Moberg & Segerberg which has a very high glabella with a sagittal ridge, showing remnants of two spines at the median line. The posterior one is possibly bent backwardly. According to Fortey (1975, p. 79), it seems to be related to his genus *Globampyx* from Spitsbergen, although it turns up considerably earlier in the Swedish strata. The dissimilarities can, however, not be denied. Others are: *Ampyx* cf. *pater*, *Geragnostus* cf. *crassus*, *G.* cf. *wimani*, *Geragnostus?* n. sp., with a long sagittal tubercle near the anterior end of the glabella (cf. Tjernvik, 1956, pl. 1, fig. 15); *Megalaspides (Lannacus) nericiensis s. l.*, *Megalaspides (Megalaspides) dalecarlicus* subsp., with a postaxial longitudinally short and slightly concave border; *Niobe* cf. *emarginula*, a fragmentary pygidium; *Niobella* n. sp., (cf. Tjernvik, 1956, pl. 5, fig. 3); the earliest *Raymondaspis* Pribyl known from Sweden: *R. brevicauda* Tjernvik, *Remopleuridiella* sp., and a fragmentary pliomerid. A fairly large orthid with strong ribs prevails in the lower part of the unit. In the upper one, which consists of a brown limestone, *Protorthis hunnebergensis* Walcott (cf. Moberg & Segerberg, 1906) is fairly common. It is a stratigraphically valuable fossil, because it abounds in the lowest portion of the graptolite zone of *Didymograptus balticus* at Mossebo, Hunneberg, in the province of Västergötland.

In the core from Finngrundet, the Transition Beds are poorly represented (as at many localities of the mainland). The only species encountered are: *Megalaspides (Lannacus) nericiensis, s. l.*, *Pricyclopyge gallica, s. l.,* and the above mentioned robust brachiopod. The upper boundary of the subdivision has been drawn at the brown-coloured top surface of a yellow limestone layer, 4 cm thick, at the level of 61,00 m.

The Transition limestone Beds of Central Sweden are very thin, at Gymninge only about 0,2 m (notice, however, that the important *planilimbata* zone is often about as thin). The beds may also be absent. In southern Sweden, that is, in Skåne or in certain parts of Hunneberg Mountain, they are matched by a few metres of graptolite shales; at Hunneberg containing trilobite specimens. Studies are now being made at Hunneberg by myself and Jan V. Johansson. The graptolite Zone of *Tetragraptus phyllograptoides* is there underlain by a limestone belonging to the Zone of *Megistaspis (Varvaspis) planilimbata*, and, as ascertained by Johansson, it is also terminated upwards by a thin limestone bed (7—8 cm thick), with a rich *planilimbata* fauna. In the drawing of my section at Mossebo (Tjernvik, 1956, fig. 5, p. 120), this bed has changed into a row of small nodules. Just above the bed or the nodules, a dark shale belonging to the Zone of *Didymograptus balticus* begins. It does not contain its index graptolite in the lower portion of the zone, and this ought perhaps to be subdivided as has been made in Norway. However, its lower layers contain, besides graptolites, also trilobites, a brachiopod species of great stratigraphical value, and conodonts.

Dr. A. Löfgren of Lund has determinated four of the conodonts. They are: *Drepanodus arcuatus*, *Oistodus lanceolatus*, *Paroistodus parallelus*, and *Prioniodus elegans.* All of these species were originally described by Pander.

Tetragraptus approximatus, a species of international importance, turns up here for good. Specimens of *Niobella bohlini s. l.* and the abundance of *Protorthis hunnebergensis* make it plausible that this shale corresponds to the Transition Beds of Närke. Further evidence occurs at Flagabro in Skåne, where small lenses of white, glauconitiferous limestone are found at the base of the *balticus* shale. They contain *Megistaspis (Varv-*

aspis) aff. *estonica*, and are rich in *Pricyclopyge gallica s. l.*

Zone of *Megalaspides* (*Megalaspides*) *dalecarlicus*

59,94—61,00 m = about 1 m thick

Above the boundary at 61,00 m, the limestone suddenly becomes red-coloured. It is mostly clayey, and contains a considerable number of bright yellow limestone layers; thin or rather thick. They represent, at least in part, discontinuity surfaces. The upper boundary of the zone has been drawn at top af a series of such surfaces, lying close up to each others.

As is the rule in the drill-core, the macrofossils are few. *Megalaspides* (*Megalaspides*) *dalecarlicus* (Holm) is the most common species. Others are: *Megistaspis* (*Varvaspis?*), sp., *Niobella* cf. *imparilimbata* (Bohlin) *sensu lato*, and *Nileus exarmatus*.

The fauna in the Swedish mainland is much richer and comprises a lot of genera and species, described or still undescribed:

A peculiar agnostid is "*Agnostus*" *toernquisti* Holm. The cephalon, with the transverse furrow in the glabella, and the pygidium with the partly effaced axis, do probably not belong to the same species. The pygidium is fairly similar to that of *Geragnostus? explanatus* Tjernvik, present in the uppermost portion of the *planilimbata* zone. Further species are: *Ampyx? obtusus*, *Ampyx pater*, *Dysplanus?* sp., *Euloma laeve* Angelin, the type species of the genus which was redescribed by Tjernvik (1956) and by Rosova (1975), p. 63), the latter with the use of excellent measurements; *Geragnostus* sp. or spp., *Geragnostus?* n. sp., present in the Transition Beds; *Harpides* sp., fragments; *Leiagnostus* sp., *Megalaspides* (*Megalaspides*) *dalecarlicus*, and *M.* (*M.*) *paliformis* Tjernvik. A large fragmentary pygidium of a *Megalaspides* (*Lannacus*) n. sp., with a very wide doublure occurs at top of the zone. Is is possibly an ancient relation of *Megalaspides striatellus* Fortey, from the middle Arenig of Spitsbergen. In Sweden, a closer relative is found in the Zone of *Megistaspis* (*Megistaspis*) *lata* in the Lanna-Volkhov Stage. *Megistaspis* aff. *ringsakerensis* (Skjeseth) has been encountered by Johansson in Närke; *Megistaspis* (*Varvaspis*), two species belonging to the *estonica* sequence have been collected from the zone at Lanna (cf. Tjernvik, 1956, p. 135), and at Norrtorpsbrottet in Närke by Johansson; *Megistaspis* (*Varvaspis*) *norvegica*, *M.* (*V.*) *scutata* Tjernvik, *Megistaspis?* n. sp., with a longitudinally very short pygidium; *Nileus exarmatus*, frequent; *Niobella imparilimbata s. l.* (= *N.* aff. *imparilimbata* in Tjernvik, 1956) is also a common species; *Pliomeroides toernquisti* (Holm), *Protopliomerops* n. sp., found by Johansson; *Raymondaspis* n. sp., *Remopleuridiella* sp., *Selenoharpes excavatus* (Linnarsson), redescribed by Whittington (1950, pp. 303—305, pl. 1, figs. 1—3); *Symphysurus* n. sp., collected by Johansson, and *Triarthrus* sp.

Several other trilobite genera and species are present, but require further research. Of special interest is the remopleuridid *Opipeuter* Fortey n. sp. which is represented by a couple of specimens encountered in a boulder of red limestone in the glacial clay of Närke. This boulder emanates, however, from the South Bothnian Bay, The species is associated with *Megalaspides* (*Megalaspides*) *dalecarlicus*. The determination was made by Fortey. According to Fortey (1974, p. 112 and footnote to p. 124), the genus is known from Utah, the Arenig of western Ireland, Sweden, and, above all, from Spitsbergen. In addition, several cranidia and a pygidium of an early ptychopygid have been found by Linnarsson and Tullberg (1882) in a clayey layer belonging to the *dalecarlicus* zone at Berg in Östergötland. They are kept in the collection of the Geological Survey of Sweden. Westergård (1940, p. 29) recognized among the species from this stratum *Megalaspides* (*M.*) *dalecarlicus* and *Ampyx? obtusus*. He named the ptychopygid "*Megalaspis* aff. *planilimbata*" in his paper. The pygidial doublure of this species is narrower than in later ptychopygids. A good specimen has been found in the upper portion of the same zone at Lanna in Närke.

Another fossil in the zone is an echinoderm, possibly a species of *Cheirocrinus* Eichwald, of which plates and broken stems may crowd a basal clayey layer at Lanna.

Zone of *Megistaspis* (*Varvaspis*) *estonica*

58,00—59,94 m = 2 m thick

The rock is red-coloured. Clayey strata alternate with such of pure, red limestone. Numerous thin layers of yellow limestone, and a thicker one, is present. The upper boundary of the zone has been drawn at the winding top surface of one of these layers. The following trilobites and some ostracods have been found in the core:

Agerina erratica Tjernvik, *Ampyx?* sp., fragmentary cranidia; *Euloma laeve* Angelin, *Megistaspis* (*Varvaspis*) *estonica*, *Nileus exarmatus*, *Niobella imparilimbata s. l.*, and ostracods of the genus *Conchoprimitia* Öpik.

In the Swedish mainland and in the island of Öland, the zone contains many other genera and species, some described, some not:

Trilobita:

Agerina erratica, frequent in clayey limestone from the upper part of the zone; *Ampyx? obtusus*, *Ampyx pater*, *Cyrtometopus priscus* Tjernvik, *Euloma laeve*, *Geragnostus* aff. *crassus* and other spp., *Geragnostus?* sp., with the median tubercle close to the anterior end of the glabella, known from underlying units; *Harpides nodorugosus* V. Poulsen, according to a determination by Poulsen; *Leiagnostus* sp., *Megistaspis* sp., a pygidium from Öland, probably belonging to an ancestor of *Megistaspis* (*Megistaspis*) *laine* (F. Schmidt); and *Megistaspis* (*Varvaspis*) *estonica*. The typical species abounds, but early forms from the basal layers resemble those from the *dalecarlicus* zone. *Menoparia? nericiensis* Tjernvik, *Metopolichas?* sp., cranidia and pygidia collected by Johansson from a bioherm at Hällabrottet in Närke; *Micragnostus* Howell sp., a cephalon from the upper strata of the zone. The determination was suggested by Fortey. *Miracybele?* sp., pygidia and fragmentary cranidia; *Nileus exarmatus*, *N. exarmatus orbiculatoides*, *Niobella imparilimbata s. l.*, *Pseudosphaerexochus* (*Pateraspis*) *praecursor* Regnéll, from the top of the zone in Öland (cf. V. Poulsen, 1965, pp. 105—106); a ptychopygid of which cranidia of an early species have been collected from the base of the zone at Lanna; *Protopliomerops* aff. *actinurus*, a cranidium found by Johansson in a bioherm at Hällabrottet in Närke, and *Protoptychopyge?* sp., pygidia from the top of the zone encountered by Johansson and myself in Närke. The species was named by Tjernvik (1956, p. 258) *Asaphus* sp.; *Raymondaspis infundibularis* Tjernvik, *Raymondaspis* sp., an old representative of a long series of forms related to *R. limbata* (*Angelin*) from the Zone of *Megistaspis* (*Megistaspis*) *limbata*; *Remopleuridiella* sp., *Selenoharpes* cf. *excavatus*, and *Symphysurus* n. sp., probably the same one as in the *dalecarlicus* zone. Some specimens were collected by Johansson from the bioherm mentioned above.

The upper boundary of the *estonica* zone, which is also that of the Latorp Stage, is somewhat obscure in the Finngrundet core, In the mainland, as a rule, it is conspicuous. In most cases it is an easily recognized surface of discontinuity covered with a coat of glauconite, and with deep but narrow pits. At Skattungbyn in Dalarna, Johansson has completed my examination of a section, and has found that the pits in the border surface in question are extremely deep and wide. The underlying limestone, which is otherwise red, has been oxidized to a considerable depth, and has a bright yellow colour. I have found a discontinuity surface of quite another kind in a small section at Lanna. Large samples of the rock were collected shortly before the section was buried beneath earth with the continued quarrying. The boundary must here be drawn at a layer of limestone, only about 1 cm thick. It has a dark-brown colour, and stands out markedly against the surrounding light-grey limestones. The upper surface is smooth. In and below this brown layer there is one of the very rare remainders of a true regression limestone. It is extremely rich in fossils, possibly due to beach conditions. As a rule, the top strata of a zone are by now almost barren in fossils. The regression layer seems to have been destroyed by an erosion acting during the withdrawel of the sea. A few cm above the boundary of the *estonica* zone at Lanna, *Megistaspis* (*Megistaspis*) *lata* Törnquist turns up in great numbers. It is an index fossil for the lowermost zone of the Lanna-Volkhov Stage.

A hiatus probably exists here. It seems to be filled out, at least to some degree, in the neighbouring Scandinavian countries. This is indicated by the results obtained at the investigations made by Skjeseth (1952) at Heramb in Norway, and by V. Poulsen (1965) at Skelbro in the island of Bornholm.

Lanna-Volkhov Stage

39,10—58,00 m = about 19 m thick

There seems to exist a strong desire among modern palaeontologists to present the Swedish and Danish countries with a Baltoscandian stratigraphical shelly facies scheme. This undertaking has not always been a very successful one. Even Männil, in his admirable paper of 1966, has had to borrow one of my Swedish sections through the Latorp Stage, in order to give some meaning to the corresponding, incomplete strata on the eastern shore of the Baltic Sea.

The overlying Volkhov Stage (or the Volkhovian) was introduced by Jaanusson (1960, p. 301) as a subdivision of his Baltoscandian shelly facies scheme. It was supposed to be valid not only for the Eastern Baltic region, but also for the corresponding strata of Scandinavia. The new term was intended to substitute the old Swedish denomination, that is, the *Limbata* Limestone, proposed by Moberg (1890). The use of the latter name was based on the fact that a long sequence of species belonging to the *Megistaspis* (*Megistaspis*) *limbata* group is very characteristic of the Stage.

Jaanusson's Volkhovian comprises:

3) Zone of *Asaphus lepidurus* (*Lepidurus* Limestone or Langevojan Substage)
2) Zone of ?
1) Zone of *Megistaspis lata*

The two lower units were included into a so-called "*Limbata*" limestone by Jaanusson, 1957, p. 155. This "*Limbata*" Limestone and an upper *Lepidurus* Limestone were enumerated in the stratigraphical scheme of an International Geological Congress Guide (Norden 1960) for the provinces of Västergötland, Närke, Dalarna, and Jämtland, all situated within the mainland of Sweden. No one seems to have noticed that the "*Lepidurus* Limestone" had not been encountered at any of the numerous localities described in the guide.

In the carefully examined section at Lanna, the vertical distribution of *Asaphus lepidurus* is restricted to the middle one third of the top Zone of *Megistaspis* (*Megistaspis*) *limbata.* It can not serve as an index fossil for a whole zone. In addition, Kohut (1972, p. 435) reports that conodonts, which could prove the existence of an Eastern Baltic Langevojan Substage, are missing in Norway. Norwegian palaeontologists seem also to look with some distrust on the introduction of new terms into Scandinavian stratigraphy, and retain the slightly modernized denominations of their old subdivisions: *Megistaspis* Limestone, *Asaphus* Shale etc.

I would have preferred to use the term *Limbata* Limestone for as long a time as possible, that is, until I am ready with my examination and description of this large stratigraphical unit. Until the present day the true distribution of its fossils has been disregarded and the scanty trilobite content of drill-cores has been examined and relied upon without any closer investigation of corresponding and much more valuable sections in adjacent quarries or natural outcrops. As a consequence, several important faunistic and stratigraphical features, characteristic of Sweden, have not been observed, or have been considered as insignificant. My use of the old term *Limbata* Limestone has been considered as improper, but it seems to me quite senseless to change this old term for a foreign one, before at least the chief outlines of the stratigraphy and fauna of this neglected Swedish subdivision are known with any certainty. Moberg's *Limbata* Limestone deserves a decent burial instead of the debasement it has been subjected to by stratigraphers, obviously ignorant of its nature. Of course, it has to be given a new name and the use of the term Lanna-Volkhov Stage has occurred to my mind.

At Lanna in Närke, the Swedish Lanna-Volkhov Stage cannot be divided into substages but into three zones, as follows:

Zone of *Megistaspis* (*Megistaspis*) *limbata*
Zone of *Megistaspis* (*Megistaspis*) *simon* n. sp. (p. 199)
Zone of *Megistaspis* (*Megistaspis*) *lata*

The two lower units agree well enough with those existing south-east of Leningrad at the Russian river Wolchow, as well as in Estonia, and the island of Öland in the Baltic Sea. The disagreement is found in the top zone where the Scandinavian fauna is of a more westerly type. To the best of my knowledge, the Swedish Zone of *Asaphus lepidurus* is represented only in Öland and its fauna looks very foreign to a palaeontologist from Central Sweden and Norway. *Asaphus lepidurus* Nieszkowsky is common, but in Öland the beautiful species *Megistaspis* (*Megistaspis*) *hyorrhina* (v. Leuchtenberg), with its elegant "nose" on the rear part of the glabella, is the most conspicuous and perhaps the most frequent trilobite in the zone. On the mainland, it has been found at several localities, but is always very rare. This species, as well as *Asaphus lepidurus*, seems to be absent in Norway.

Nevertheless, the introduction by Jaanusson of a *Lepidurus* Limestone, overlying a "*Limbata*" Limestone throughout Sweden, has been regarded as a great improvement of Moberg's scheme and his "revision" has been given much publicity in the literature, as widespread as false. Certainly, he and Dr. Mutvei had sought in vain for a *Lepidurus* Limestone at Vikarbyn in Dalarna. They wrote, Jaanusson & Mutvei (1951, p. 630), that "The *Lepidurus* beds, however, seem to be missing in the section, the hiatus being marked by a distinct discontinuity surface at the base of the *Vaginatum* limestone". They might have found the missing subdivision at Skattungbyn, about 30 km north of Vikarbyn. It is, however, not the *Lepidurus* Limestone of Öland but the mainland Zone of *Megistaspis* (*M.*) *limbata.* Its thickness is only about 0,3 m, but the stratum is rich in fossils. It is grey-coloured, and overlies the red limestone of an unusually well developed Zone of *Megistaspis* (*M.*) *simon.*

Jaanusson's efforts to revise the Swedish stratigraphical scheme have been accepted without misgivings. The name "*Limbata*" Limestone (in Swedish "limbatakalksten") has been applied to the mainland stage by, for instance, the Geological Survey as late as in 1972. At the same time, the originally Eastern Baltic term *Vaginatum* Limestone (vaginatumkalksten, without any quotation

marks) has been used unscrupuously, in spite of the fact that *Catoraphiceras? vaginatum* (Schlotheim) is not restricted to this large, overlying subdivision. Its strata have been thoroughly examined in Sweden and Norway by Johansson, who has found that they contain a most complicated succession of faunas. He has also collected a very large material from Angelin's "Black Orthoceras Limestone" at Fågelsång in Skåne which may perhaps occupy a hiatus between the Zone of *Megistaspis* (*M.*) *limbata* and that of *Asaphus expansus*.

As regards the uncertainty of the existence of a Swedish equivalent to the Baltoscandian Kunda Stage, another discrepancy has become manifest. Johansson has studied the many species of the genus *Asaphus*, several still undescribed, which are characteristic of the stage. He has stated that the true *Asaphus raniceps* Dalman is restricted to the lowermost Swedish Zone of *Asaphus expansus* (as well as to the corresponding unit of Norway). There, it can be as frequent as *expansus* itself. The overlying zone was called the Limestone with *Asaphus "raniceps"* by Bohlin & Jaanusson (1955). Jaanusson (1960) named this upper subdivision the Zone of *Asaphus raniceps* in his Baltoscandian scheme. However, Johansson has found that the species *A. raniceps* does not occur in the zone in question in Sweden. This has become an intricate problem.

Because of this fact, the denomination Kunda Stage of Sweden has been exchanged for a question mark in my stratigraphical scheme.

The Lanna-Volkhov Stage has been the main object of may research during the last years. This large and widespread limestone sequence and its fauna has been neglected for a long time, and for good reasons. In the middle of the southern mainland it once delivered an excellent building stone. Its hard and tough, and the fossils break easily on their extraction from the rock. Furthermore, the specimens collected are usually internal moulds. The dorsal surface adheres so strongly to the limestone that the sclerites can not be loosened or removed by preparation, for the obtaining of casts. Whole specimens, with exception of those in *Nileus*, are extremely rare.

I have studied this difficult fauna for many years in several parts of Sweden (and to some extent in Norway), always comparing my experiences with those made at Lanna in Närke. At this locality I have drawn up a biostratigraphical reference section in a large limestone quarry where the strata rest undisturbed since their sedimentation and lithification. The fossils have been collected centimetre by centimetre throughout the whole stage, in order to make it possible to place the specimens with accuracy into a chronological order. This task has been much facilitated by the fact that the limestone at Lanna can be divided by discontinuity surfaces into a great number of (about 130) small phases, as a result of a pulsatory rhythm in the sedimentation which is also known from the Latorp Stage. They have given me a reliable knowledge of the various faunas which characterize the three zones into which the stage can be subdivided. Some conspicuous discontinuity surfaces or series of well-defined ones, as well as the vertical distribution of the fossils, have made it relatively easy to draw the boundaries between the zones. Unfortunately, most part of the material secured from Lanna and other quarries of the Swedish mainland is still undescribed, and can not be treated in these brief paragraphs. The enormous number of fossils obtained from the mainland have brought to light an evolutionary sequence that seems to have turned several of the so-called species into vertical "series" of forms which may grade more or less imperceptibly into each other. The description of these rather peculiar species and their branches of subspecies needs much further labour and time. Therefore, only short remarks in the text or diagnoses at the end of this paper must suffice at my dealing with the scant fauna encountered in the core. They are accompanied by illustrations of defective specimens from the core or by better ones obtained elsewhere. The complicated evolutionary trends are especially characteristic of the genera *Nileus*, *Niobella*, and *Raymondaspis*, but also for a couple of endemic forms belonging to *Megistaspis* (*Megistaspis*) which genus, however, to a great degree is imperfectly known, because of the scarcity of good cephala. Only a few species of this genus are identical with Eastern Baltic ones. In addition, several Scandinavian genera have only been mentioned casually, because this material of mine is or will be investigated by specialists. A preliminary determination of the ostracods and some trilobites has been made by Dr. L. Karis at the Swedish Geological Survey.

It ought perhaps to be mentioned that a new, thorough investigation and description of my reference section at Lanna, and its faunas, has been under way for a considerable time.

Zone of *Megistaspis* (*Megistaspis*) *lata*

51,07—58,00 m = about 7 m thick

The rock is still red and clayey beds alternate with such of pure limestone. Thin layers of yellow limestone are comparatively rare. The upper

boundary is drawn at 51,07 m, where there is a conspicuous yellow discontinuity surface, with deep pits containing and overlain by rather scarce grains of glauconite. The fauna of the core comprises the following trilobite species:

Agerina sp., *Cyrtometopus* sp., *Megalaspides* (*Lannacus?*) n. sp., in the lowest strata; *Megistaspis* (*Megistaspis*) *lata*, *Megistaspis* sp., *Metaptychopyge* cf. *herambensis* (Skjeseth), *Nileus exarmatus*, *N. glazialis* (Schrank) subsp. no. 1, *Niobella imparilimbata s. l.*, in the lowest part of the zone; *Protoptychopyge prisca* (Lesnikova), and *Remopleuridiella* sp.

A number of ostracods from the zone belong to the genus *Conchoprimitia.*

Within the Swedish mainland the fauna is very much richer, and comprises the trilobite species:

Agerina sp., *Ampyx* aff. *pater*, *Ampyx?* cf. *linnarssoni* F. Schmidt, *Cyrtometopus* sp., *Geragnostus* spp., *Megalaspides* (*Lannacus?*) n. sp., in the lowest beds only (cf. the remarks below); several *Megistaspis* (*Megistaspis*) spp.: *M.* (*M.*) *lata*, *M.* (*M.*) aff. *simon* n. sp., pygidia from the base of the zone, possessing a broad axis similar to that of *M.* (*M.*) *simon*; *M.* (*M.*) n. sp. no. 1, in the lower half of the zone (cf. the end of the paper); *M.* (*M.*) n. sp. no. 2, in the upper half of the zone (cf. the end of the paper); *Menoparia?* sp., *Metopolichas?* n. sp., a cranidium from the basal limestone bed of the zone, found at Ösby in Närke(cf. the remarks below); *Metaptychopyge herambensis* (Skjeseth), and *M. minor* (Skjeseth) in the lower half of the zone; *Nileus exarmatus*, *N. exarmatus orbiculatoides* Schrank n. sp. or subsp., *N. glazialis glazialis* (Schrank), at top of the zone; *N. glazialis* subsp. no. 1, in all the zone (cf. the end of the paper); *Niobella imparilimbata sensu stricto* and *N. imparilimbata sensu lato*, both forms at the base of the zone; *Niobella* cf. *lindstroemi* (F. Schmidt), at top of the zone; *Panderia* sp., in the upper part of the zone; *Protoptychopyge prisca*, with a wide vertical range; *Raymondaspis limbata* (Angelin) subspp., two primitive forms of pygidia occurring throughout the zone; *Remopleuridiella* sp., a few fragmentary cranidia; *Selenoharpes* n. sp., and *Trinodus* sp.

Remarks on the above genera and species:

Cyrtometopus sp. was encountered in the basal strata of the zone at Latorp in Närke, and seems to be closely related to *C. priscus* Tjernvik, from the underlying *estonica* zone.

Megalaspides (*Lannacus?*) n. sp. is found in the basal transgression limestone of the zone. The species is possibly related to *Megalaspides striatellus* Fortey, from Spitsbergen. The preglabellar field is transversally wide and the pygidium possesses a broad doublure.

As regards the cranidium of *Metopolichas?* n. sp., from the base of the zone, the following can be reported: A good pygidium of a *Lichas sensu lato* was described and figured by Regnéll (1942, pp. 14—15, text-fig. 7). It was collected from a limestone boulder emanating from strata near the boundary between the *estonica* and *lata* zones at Köpings Klint in Öland. Skjeseth (1952) recorded the find of fragments of a lichid at Heramb in Norway. It seems to be of approximately the same age as the species from Öland. V. Poulsen (1965, p. 107, pl. 9, fig. 11), described a pygidium of *Metopolichas?* sp. indet. from the basal Volkhovian Zone of *Cyclopyge stigmata* at Skelbro in the island of Bornholm. Finally, Johansson has recently collected specimens of an early lichid from the uppermost strata of the *estonica* zone at Hällabrottet in Närke.

Zone of *Megistaspis* (*Megistaspis*) *simon*

45,48—51,07 m = about 5,6 m thick

The limestone is as red as in the preceding zone. Thick clayey layers alternate with such of pure limestone. Glauconite grains are very rare. Yellow discontinuity surfaces are also scarce, and may be exchanged for red ones. The upper boundary is drawn at the top of a small series of yellow surfaces, at 45,48 m.

The trilobites collected from the core are:

Agerina sp., *Cyrtometopus* aff. *clavifrons* (Dalman), *Geragnostus* sp., *Harpides* aff. *rugosus*, according to a kind determination by Whittington; *Megistaspis* (*Megistaspis*) *simon*, *M.* (*M.*) *limbata* n. subsp., *M.* (*M.*) n. sp., *Metaptychopyge* cf. *praecurrens* Balashova, a fragmentary and distorted cranidium in the basal strata; *M.* cf. *truncata* (Nieszkowsky), a pygidium at top of the zone; *Nileus exarmatus*, *N. glazialis glazialis*, *N. orbiculatoides*, *Niobella lindstroemi*, *Paraptychopyge* cf. *plautini* (F. Schmidt), a fragmentary cranidium; *Remopleuridiella* sp., a small cranidium; and *Raymondaspis limbata* subsp.

Some ostracods have been examined by L. Karis. They belong to *Conchoprimitia grammae* Öpik and other species of the same genus. In addition, there are some undescribed orthoid brachiopods, and a *Lycophoria?* sp.

The mainland fauna contains the following trilobite species:

Agerina sp., *Ampyx pater nasutus* Dalman, *Celmus* sp., librigenae; *Cheirurus?* sp., fragmentary cranidium; *Cyrtometopus* aff. *clavifrons* Dalman, small cranidium and hypostoma; *Geragnostus* sp., scarce; *Harpides* sp., *Megistaspis* (*Megistaspis*) *limbata* n. subsp., *Megistaspis* (*M.*) *simon* n. sp. (cf. the diagnosis at the end of the paper); *M.* (*M.*) n. sp. no. 3, undescribed; *Metaptychopyge truncata*, *Nileus exarmatus*, *N. exarmatus orbiculatoides*, *N. orbiculatoides*, a very good index fossil for the middle and greater part of the zone; *N. glazialis glazialis*, *Niobella lindstroemi*, very frequent; *Panderia* sp., frequent; *Paraptychopyge plautini*; the cranidium of an early and undescribed proetid, according to a determination by Karis; *Raymondaspis limbata* subsp., *Remopleuridiella* sp. and *Trinodus* sp., scarce.

Among the many cephalopods of the zone, a *Catoraphiceras?* aff. *vaginatum* (Schlotheim) has been found. Further, several undescribed orthoid brachiopods and a *Lycophoria* sp. occur.

Remarks on the fauna:

Megistaspis (*Megistaspis*) *limbata* n. subsp. differs from the Norwegian type species in its cranidium being considerably wider in front of the eyes. In this respect the form resembles occasionally in outline those which occur in the Eastern Baltic region. The pygidium, on the contrary, can hardly be distinguished from that of the true *limbata*, because its posterior is also upwardly directed.

Nileus exarmatus orbiculatoides: The anterior margin of the cranidium in this intermediate form possesses a distinct point or a tongue-like process at the median line. The pygidium differs from that of *N. orbiculatoides* in having a narrow but conspicuous depression, subparallel to the lateral and posterior margin, just as in *N. exarmatus*. In *N. orbiculatoides* the pygidium is quite convex. The ornament of the dorsal surface of the pygidium (an important feature in *Nileus*) consists of sparse but distinct terrace lines which cover transversally all the pleural fields as in the true *orbiculatoides*. They differ strongly from those in *N. exarmatus*. The intermediate form seems to turn up as early as in the upper strata of the Latorp Stage.

Niobella lindstroemi: The pleural fields of the pygidium are quite smooth. Small pygidia of the species resemble the transitory forms of *Niobe quadraticaudata* (Billings), described and figured by Whittington (1965, p. 362, pl. 27, figs. 5—7). They have a more or less distinct postaxial ridge, a feature which is unknown in any other *Niobe* or *Niobella* spp. from Sweden.

Zone of *Megistaspis* (*Megistaspis*) *limbata*

39,10—45,48 m = about 6,4 m thick

The rock is red-coloured. Clayey layers, sometimes unusually thick, alternate with beds of pure limestone. Thin layers of yellow limestone occur in abundance, as in the underlying zones. The upper surface of several of these layers possess deep pits, the bottom of which is covered with a film of glauconite. They undoubtedly answer to discontinuity surfaces. Such a yellow surface, at 39,10 m, is overlain by a slightly conglomeratic limestone containing small corroded pebbles of limestone or loosened fragments of fossils impregnated with glauconite. This surface is regarded as the upper boundary of the zone.

The fauna of the core comprises the following trilobites:

Agerina sp., *A. tuberculata* Karis (MS), *Ampyx* spp., *Apheloshumardia parvuncula* Karis (MS), *Asaphus lepidurus* Nieszkowsky, in the middle of the zone; *Celmus* sp., *Harpides* sp., *Megistaspis* (*Megistaspis*) *limbata* (Boeck), *Metaptychopyge truncata*, pygidia; *Nileus exarmatus* subsp., *N. glazialis glazialis*, *N. glazialis* subsp. no. 2, *Niobella* sp., *Panderia* sp., specimens belonging to this genus are much more scarce in the core than in the limestone sequence at Lanna; *Raymondaspis limbata*, and *Remopleuridiella* sp.

Ostracods are very frequent in the clayey beds. These have been determined by L. Karis as follows:

Aulacopsis plana, *Conchoprimitia* sp., *Glossomorphites acuta*, *G. tenuilimbata*, *G.* n. sp., *Primitia* sp., *Protallinella* sp., *Steusloffia* sp., and *Tallinellina* spp.

In addition, there are several undescribed orthoid brachiopods.

The zonal trilobite fauna of the mainland is richer, and contains:

Agerina sp. or spp., *Ampyx* sp., *A.* aff. *nasutus*, *Asaphus lepidurus*, in the middle of the zone; *Celmus* sp., *Cybele* aff. *bellatula* (Dalman), *Cyrtometopus* cf. *clavifrons*, *Dysplanus acutigenia* Jaanusson, *Geragnostus* sp., *Harpides* sp., *Megistaspis* (*Megistaspis*) *limbata*, *M.* (*M.*) *limbata* n. subsp., in the lower part of the zone; *M.* (*M.*) *minor* (Brögger), *M.* (*M.*) *hyorrhina*, scarce; *Megistaspis* (*Megistaspidella*) aff. *acuticauda* (Angelin), *Nileus exarmatus* n. subsp., with a subquadratic glabella; *N. glazialis glazialis*, *N. glazialis* n. subsp. no. 2, with a convex pygidium; *Niobella* n. sp., *Panderia* sp., ptychopygids, *Raymondaspis limbata*, with a short pygidial axis;

Remopleuridiella sp., *Symphysurus* n. sp., in the lower portion of the zone, and *Trinodus* sp.

The cephalopod *Catoraphiceras? vaginatum* makes its appearance in the upper part of the zone.

Remarks on the fauna:

Nileus glazialis n. subsp. no. 2 differs from the type species in having a convex pygidium. It seems to be closely related to *N. glazialis costatus* Fortey, from the middle Arenig of Spitsbergen.

Niobella n. sp.: Its pygidial pleural furrows are short but unusually deep, in contrast to those of the species in the under- and overlying zones which have quite smooth pleural fields. Its specimens are rather scarce in Sweden, while they are common in the Norwegian *Megistaspis* Limestone and the lowest part of the *Asaphus* Shale.

The ptychopygids in the hard limestone at Lanna are, as a rule, fragmental, and must be objected to more thorough examination.

It is most unfortunate that the trilobites of the Finngrundet core have had to be dealt with before the pertinent mainland species have been described. I hope, however, that I have at least been able to give an account of the general outlines of the various trilobite assemblages which characterize the zones of the Latorp and Lanna-Volkhov Stages.

Summary

A drill-core obtained from the bottom of the South Bothnian Bay at Finngrundet has been described biostratigraphically. The examination has comprised the limestone sequence which belongs to the early Ordovician Latorp Stage and the overlying larger unit, here called the Lanna-Volkhov Stage. Very little has been known of the latter. The corresponding limestone in the island of Öland in the Baltic Sea has been described by Bohlin (1949) and by Bohlin and Jaanusson (1955). However, extensive examinations of the same strata in the mainland of Sweden (and to some extent in Norway) have made clear that the stratigraphy of these strata do not agree with those of Öland and of the Eastern Baltic region. The Lanna-Volkhov Stage of the mainland and the Finngrundet core has therefore been subdivided in an independant way, that is, without any foreign Langevojan Substage, but only into the three following zones:

Zone of *Megistaspis* (*Megistaspis*) *limbata*
Zone of *Megistaspis* (*Megistaspis*) *simon* n. sp.
Zone of *Megistaspis* (*Megistaspis*) *lata*

The Zones of *Asaphus expansus* and *Asaphus "raniceps"*

By Jan V. Johansson

The total thickness of the two zones is about 20,8 m (18,33—39,10 m).

Lithology:

As in the *limbata* zone, the limestone is mostly red, except for a few intervals where greyish green limestone dominates. It is generally clayey and beds of pure limestone are rare. Lithologically, it agrees well with the corresponding sequence at Kinnekulle. There are a large number of discontinuity surfaces. They are yellow, and amount to no less than 121. They appear throughout the whole series of layers except in the middle of the *"raniceps"* zone where only a few occur. They probably represent short breaks in the sedimentation, and were usually formed subaqueously. There are also nine very thin (only one mm thick) red, winding horizontal lines in the portion 33,5—34,5 m and at about 38,5 m. The only occurrence of glauconite is found just above 39,10 m where the pits in a discontinuity surface and a fragment of a cephalopod are covered with a thin coat of glauconite. This level is supposed to be the boundary between the Zone of *Megistaspis limbata* and that of *Asaphus expansus*. It is remarkable that the hiatus between these two zones, which is evident from faunistic reasons, and which seems to represent a long time interval, is so slightly marked lithologically. This is probably due to the fact that glauconite grains are not so easily formed in such red clayey strata (cf. below). The fossils in the core are mostly poorly preserved. Slide surfaces on the specimens are not unusual. In the *expansus zone*, the fossils often stand on edge, a condition which is common in the beds of this zone also in other Swedish provinces and in the Oslo area (cf. Bohlin, 1949). There is no trace of a *Sphaeronites* bed in the lowest part of the *"raniceps"* zone. This is found in Västergötland and in the southern part of Öland. The transition to the *"raniceps"* zone in the core, as well as in other areas, seems to be more or less complete. The boundary to the *expansus* zone has been chosen at a surface of discontinuity at 32,30 m in the core.

Remarks:

The geographical distribution of less marked discontinuity surfaces of the *"raniceps"* zone is certainly limited. The thin and winding red lines,

the nature of which has not yet been explained, also occur in the lower *expansus* zone in Östergötland and Närke. The hiatus between the *limbata* and *expansus* zones is only slightly marked also in South Central Sweden: Västergötland, Östergötland, Närke, and Dalarna. Glauconite grains are scarce in the *expansus* zone at Kinnekulle where the stage of transition is difficult to establish. In all other provinces mentioned above, the transition between the *limbata* and *expansus* zones is well marked, above all in Östergötland where the *expansus* zone begins with glauconitic sediments, the thickness of which is 1,5 m. In this connection, it ought to be mentioned that the Skåne-Oslo area probably never emerged during the regression between the *limbata* and *expansus* ages which seems evident from the fact that there is no true faunal gap in the Oslo area.

Fauna in the core:

I have only determined macrofossils, but about 50 ostracod specimens have been picked out. The recognized fossils are as follows:

I. Zone of *Asaphus expansus* (and *A. raniceps sensu* Dalman), about 7,8 m thick (32,30—39,10 m).

Trilobita:

Ampyx nasutus, *Asaphus expansus* (Linnaeus) of which only one relatively well preserved cranidium has been found at 32,42 m, and a poorer one at 37,75 m; *Asaphus* n. sp. at 36,58 m (cf. the remarks below); *Celmus granulatus* Angelin, *Illaenus sarsi* Jaanusson, *I. incisus* Jaanusson, at the very top of the zone; *Megistaspis* (*Megistaspidella*) *acuticauda* (Angelin), *Nileus* cf. *armadillo* (cf. below); *N. glazialis* n. subsp. no. 2, known from the *limbata* zone; *Niobella laeviceps* (Dalman), a well preserved specimen at 37,33 m; *Panderia* cf. *ramosa* Bruton, and *Trinodus* or *Geragnostus* sp.

Remarks:

Araphus n. sp. (cf. fig. 9 J) is distinguished from *A. expansus* essentially because of its considerably longer and more pointed cranidium. It also differs completely from *A. lepidurus* which occurs in the *limbata* zone. It is identical with an undescribed *Asaphus* sp. which is characteristic of the upper portion of the *expansus* layers of northern Östergötland. It has also been found in boulders from northern Öland.

The true *Asaphus raniceps*, that is, *A raniceps* (Dalman, 1827) is restricted to the Zone of *Asaphus expansus*, where it may be as frequent as *expansus*.

Nileus cf. *armadillo*; five specimens have been encountered. They differ from *N. armadillo* (Dalman) mainly in their small size.

Brachiopoda:

Ahtiella sp., *Ingria* sp., *Iru zonata* (Dalman), and *Lycophoria nucella* (Dalman). *Orthis callactis* (Dalman) has been collected from several levels. The lowest ones occur immediately above the border to the *limbata* zone. In addition, there are some orthoid brachiopods, not determinable.

Other fossils are fragmentary cephalopods, gastropods, and *Bolboporites* sp.

Ostracoda, according to determinations made by L. Karis:

Aulacopsis plana, *Conchoprimitia gammae*, *C. sociale*, *C.* sp., *Euprimitiinae* n. gen. and n. sp., *Glossomorphites* spp., *Laccochilina* sp., *Primitiella* sp., *Sigmobolbina* n. sp., and *Steusloffia* spp.

II. Zone of *Asaphus "raniceps"*, about 14 m thick (18,33—32,30 m).

Trilobita:

Agerina sp., *Ampyx nasutus*, *Asaphus "raniceps"*, with a sagittally longer carapace than in the true *raniceps*; *Celmus granulatus*, *Illaenus aduncus* Jaanusson, a well preserved pygidium; *I. incisus*, near the bottom of the zone: *Megistaspis* (*Megistaspidella*) sp., *Pliomera fischeri* (Eichwald), *Pterygometopus sclerops* (Dalman), *Ptychopyge* sp., a fragmentary hypostoma, and a trilobite species, an interesting, undescribed form.

Brachiopoda:

Ingria sp., *Orthambonites calligramma* (Dalman).

Ostracoda:

A great number of ostracods have been encountered in the zone. They are, according to a preliminary examination by L. Karis.

Aulacopsis plana, *Conchoprimitia* spp., *Euprimites* sp., *Glossomorphites* sp., *Laccochilina* sp., *Ogmoopsis* sp., *Pinnatulites procera*, *Primitia* sp., *Protallinella grewingkii*, *Sigmobolbina* sp., and *Steusloffia polynodulifera*.

In addition, four fragmentary cephalopods have been found in the upper part of the zone.

Summary

The *expansus* and *"raniceps"* beds of the core contain species occurring in the corresponding zones of the Swedish mainland. No evi-

dence of transitional beds between the Zone of *Megistaspis limbata* and that of *Asaphus expansus* have been found, from a faunal point of view. As there are many discontinuity surfaces, the sequence is probably incomplete, with sedimentary gaps, but from the few fossils occurring in the core it is impossible to determinate if any subzones are missing or not. However, the *expansus* layers of the core might represent only an upper subzone, characterized by *i. a. Asaphus* n. sp. and a common occurrence of species of the genus *Ahtiella.*

Taxonomic section

By T. E. Tjernvik

Megistaspis (*Varvaspis*) n. subgenus
Figs. 6 and 8 A—I

Angelin, 1851: *Megalaspis*
Jaanusson, 1956: *Megistaspis*
Tjernvik, 1956: *Plesiomegalaspis*

In 1956 I identified the subgenus *Varvaspis* with *Plesiomegalaspis* Thoral (1946). I have by now accepted a Scandinavian interpretation, and included the subgenus with *Megistaspis* Jaanusson. Yet, *Varvaspis* seems to be more closely related to the two other subgenera of *Megistaspis*, that is, to the early *Ekeraspis* and the late *Megistaspidella* than to *Megistaspis* (*Megistaspis*) itself.

NAME. — *Varvaspis* alludes to a Varvsberget mountain in Västergötland from which Angelin collected and described the type species of the subgenus.

TYPE SPECIES. — *Megalaspis planilimbata* Angelin, 1851.

TYPE STRATUM and TYPE LOCALITY. — Thin layer of grey limestone at Oltorp in Västergötland.

DIAGNOSIS. — The subgenus differs from that of the later *Megistaspis* (*Megistaspis*) in the following features: The dorsal surface of the glabella is completely smooth, without any trace of an occipital furrow. In *M.* (*V.*) *planilimbata* there is a broad and shallow posterior border furrow which has disappeared in the later *M.* (*V.*) *estonica.* The genal spine is always strong and comparatively broad. The hypostoma undergoes an evolution which was observed by G. Lindström (1901) in *M.* (*V.*) *planilimbata.* In this species, the earliest hypostomas have a convex posterior margin which may form an obtusely tongue-like process. This process has later been bent upwards, that is, in a dorsal direction, and been reduced. In later specimens, the posterior margin is straight. The species disappears at top of the *planilimbata* zone, and is replaced by an "*estonica* series" in the Billingen Substage. Here an evolution in the hypostoma similar to that in *M.* (*V.*)*planilimbata* has been observed. The first member of this series, *M.* (*V.*) aff. *estonica*, makes its appearance in the Transition Beds at the base of the Billingen Substage. Its hypostoma has a convex posterior margin. In *M.* (*V.*) *estonica*, at top of the substage, this margin is concave.

In the thorax, the distal ends of the rather low axial rings are slightly and evenly rounded. The pygidial border is flattened or concave. Finally, in the *planilimbata-estonica* series there is an evolutionary trend towards a transversely broader carapace.

OCCURRENCE. — *Megistaspis* (*Varvaspis*) occurs in the Latorp Stage, where it shows up in the Zone of *M.* (*V.*) *planilimbata* of Sweden, and in the corresponding strata of Norway. According to Johansson, one single specimen of the subgenus has been encountered at the very base of the Lanna-Volkhov Stage. The rich occurrence of specimens of several species belonging to the *Megistaspis* (*Varvaspis*) group is characteristic of Sweden.

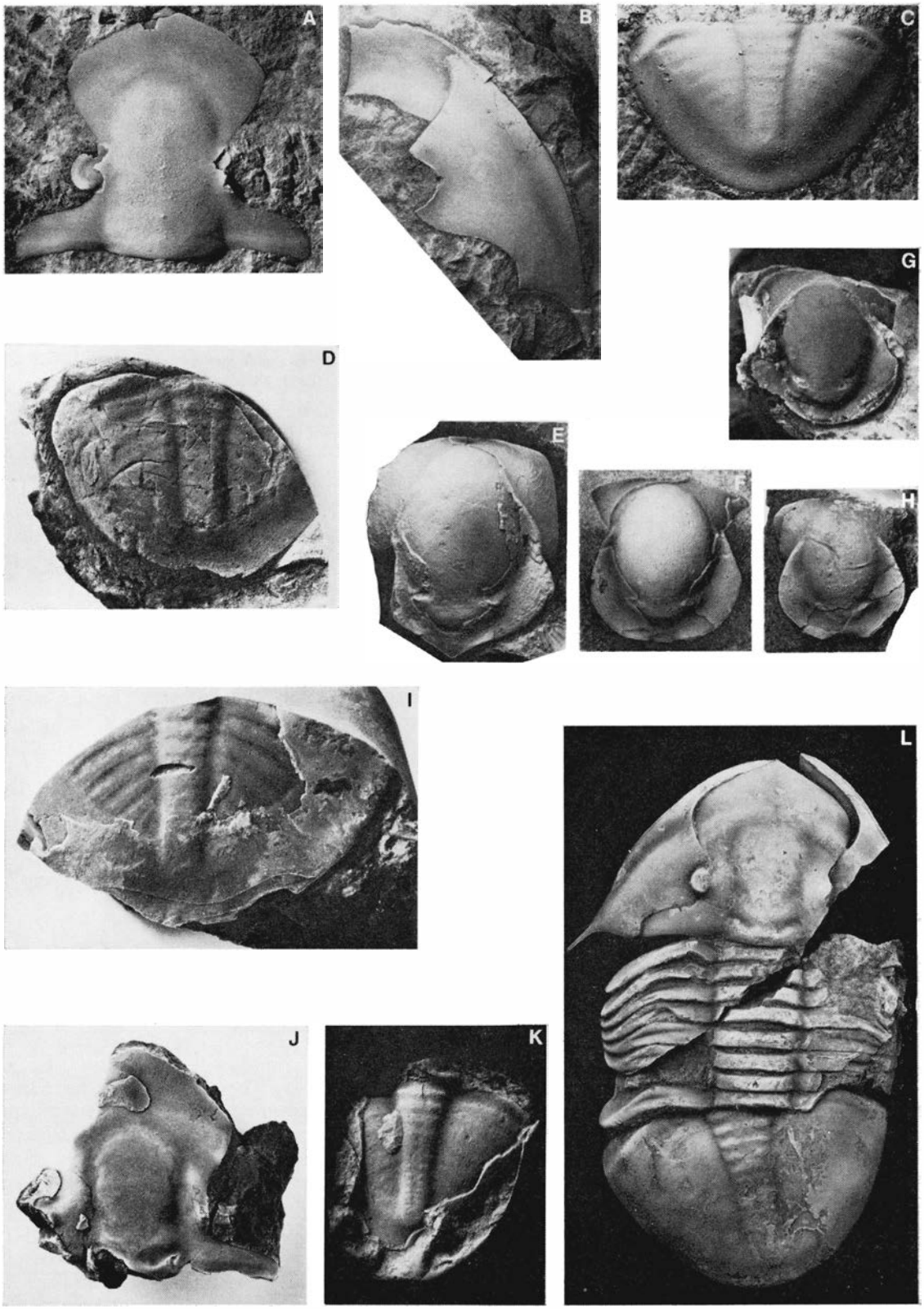
Megistaspis (*Megistaspis*) Jaanusson, 1956
Figs. 7, 8 J—L, and 9 A—H

TYPE SPECIES. — *Trilobites limbatus* Boeck, 1838.

LECTOTYPE. — Selected by Størmer (1941). Illustrations of this specimen were published by Jaanusson (1956).

TYPE STRATUM. — Probably the lower *Asaphus* Shale (3cβ) in Norway.

DIAGNOSIS. — The subgenus differs from *Megistaspis* (*Varvaspis*) in the following features: An occipital ring in the cranidium is indicated by the remainders of an occipital furrow, represented by two pronounced lateral depressions, disconnected at the middle of the glabella. I follow here the description made by Bohlin (1960, p. 158). In small, juvenile specimens, as well as in internal moulds, the occipital furrow may, however, be fully developed. Posterior border furrows


A
B
C
G
D
E
H
I
L
J
K

are absent, at least in the dorsal surface of the fixigenae. In the species from the Lanna-Volkhov Stage the posterior margin of the hypostoma seems always to be concave. The axial rings of the thorax are more convex than in *M.* (*Varvaspis*). The anterolateral portion of the pygidial border is convex; the posterolateral one more or less concave (compare, however, *M.* (*M.*) *lata* below). The axial rings in the pygidium of *M.* (*Varvaspis*) are evenly flattened and longitudinally uniformly broad, while those in *M.* (*Megistaspis*) have slightly elevated lateral ends which curve minutely forwardly, then posteriorly, and terminate distally with an obtuse edge. These edges are most conspicuous in the internal moulds where they resemble those in the genus *Asaphus*. A posterior portion of the cranidium and an anterior part of the pygidium are sufficient to distinguish species of the subgenera *M.* (*Varvaspis*) and *M.* (*Megistaspis*) from one another.

Megistaspis (*Megistaspis*) comprises a multitude of species and subspecies, the evolution of which is bewildering. Sometimes, a trend towards a transversely more narrow carapace is discernible. Only a few species can be mentioned here, and most of the forms can not be identified with Eastern Baltic ones.

OCCURRENCE. — *Megistaspis* (*Megistaspis*) is extremely characteristic of the Lanna-Valkhov Stage. One single pygidium, named in the page 188, *Megistaspis* (*M.*) aff. *laine*, has been collected from the uppermost zone of the Billingen Substage in Öland.

Megistaspis (*Megistaspis*) *lata* (Törnquist)
1884 *Megalaspis limbata* Boeck, forma *lata* Törnquist

Figs. 7 A, 8 J—L, and 9 A

Thanks to the kindness of Dr. V. Jaanusson of the State Museum, an almost whole specimen can be illustrated here. The carapace is oval in outline. It is broader than in any other Swedish species of the genus. In consequence, the cranidium is also broad; the greatest transversal width in front of the eyes being about four fifths of the sagittal length. The palpebral lobes are very small, and hardly rise above the surface of the glabella. There is no posterior border furrow. The genal spines are short and slender, curving outwards. Posterior margin of hypostoma concave. The greatest width of the pygidium is almost one and a half of the sagittal length. As a rule, the anterolateral portion of the pygidial border is convex; the posterolateral one concave. Yet, in early specimens, and especially in juvenile ones, the border may be flattened. The pygidial axis rises above the surfaces of the pleural fields.

The species was excellently described by F. Schmidt (1906) under the name of *Megalaspis polyphemus* var. *Törnquisti*. The holotype, a cranidium illustrated by Törnquist (1884), and here in fig. 8 J, is too badly damaged to give a true image of that of the genus.

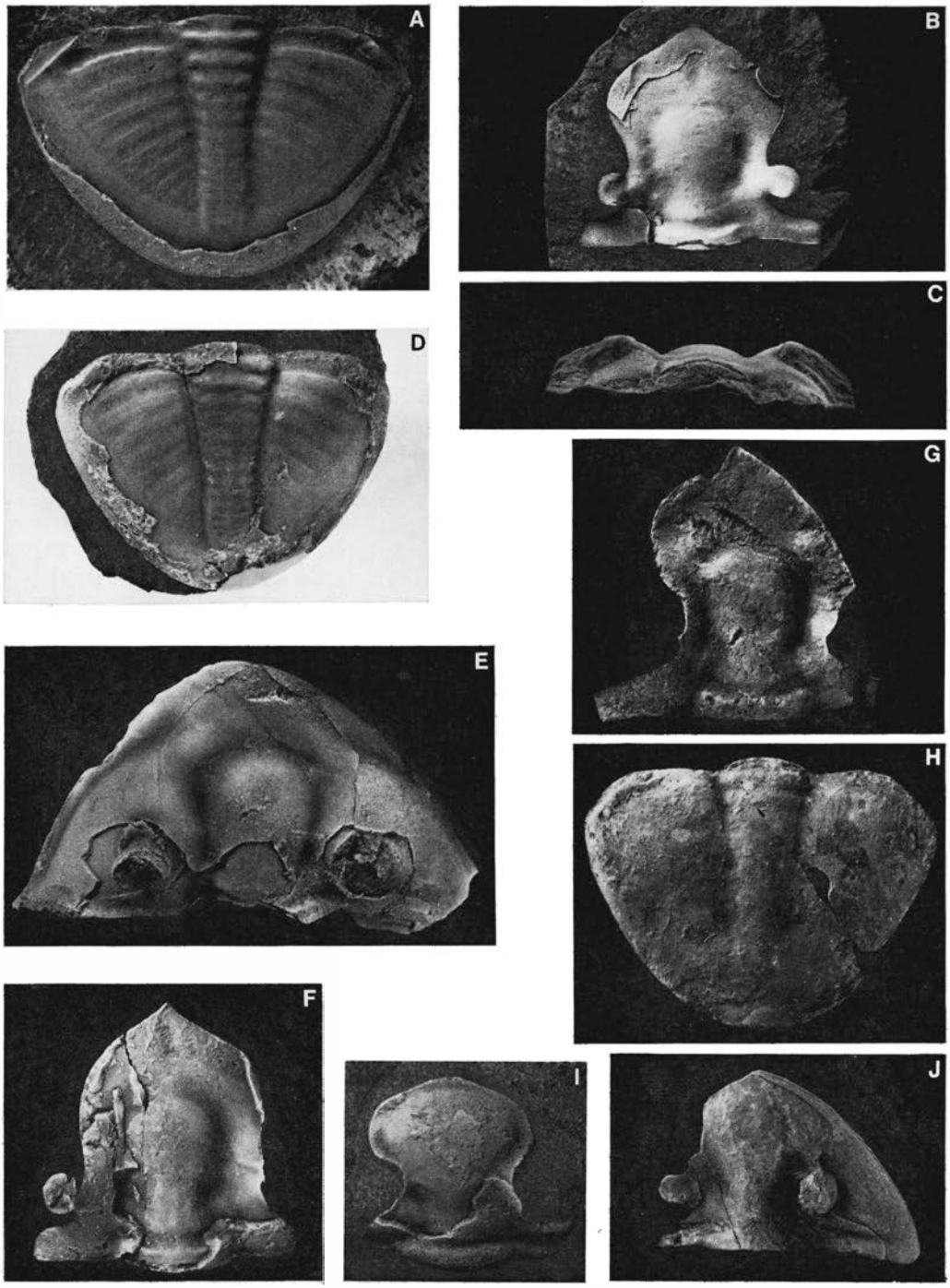
OCCURRENCE. — Very frequent in the Zone of *Megistaspis* (*M.*) *lata*. It is now known that the lowermost beds of the thick limestone sequence of Lanna-Volkhovian age on the islet Andersön in Lake Storsjön, Jämtland (Tjernvik, 1956, pp. 172—173), contain good specimens of *Megistaspis* (*M.*) *lata*.

Megistaspis (*Megistaspis*) n. sp. no. 1

Fig. 7 B

At a cursory glance, a specimen of this elegant form seems to resemble very much the type species of *Megistaspis* (*M.*) *limbata*. The transversal width of the cranidium in front of the eyes is unusually small. The glabella is obtusely rounded or very slightly pointed at its anterior end. The lateral

Figs. 8—10. Remarks: All the specimens illustrated were photographed, after whitening with ammonium chloride. The rock surrounding the fossils was retouched by the author. The plates were mounted by Mrs. D. Engström.
Abbreviations: LO = Dept. of Historical Geology and Palaeontology, Lund. — PU = Palaeontological Institute, Uppsala. — RM = Riksmuseum (State Museum), Stockholm. — S.G.U. = Geological Survey of Sweden, Stockholm. — B = Bothnian Bay, N = Närke, Vg = Västergötland, Ög = Östergötland, Öl = Öland. — Lanna (R 8.58 m) = Reference section at Lanna, Närke, 8.58 m above the lower boundary of the Lanna-Volkhov Stage.
Fig. 8 A—F: *Megistaspis* (*Varvaspis*) *planilimbata* (Zone of *M.* (*V.*) *planilimbata*). □A: Cranidium. PU no. N 246. Lanna. × 2,4. From Tjernvik 1956, Pl. 6:1. □B: Internal mould of librigena. PU no. N 32. Latorp. × 1,2. From Tjernvik 1956, Pl. 6.2. □C: Pygidium. PU no. Öl 296. Grönviken. × 2,4. From Tjernvik 1956, Pl. 6:6. □D: Internal mould of pygidium. B no. 312. Finngrundet core: 61,55 m. × 1,2. □E: Early hypostoma. PU no. N 914. Vilhelmsberg. × 1,8. From Tjernvik 1956, Pl. 6:4. □F: Late hypostoma. PU no. Öl 285. Grönviken. × 3. From Tjernvik 1956, Pl. 6:8. □G: *Megistaspis* (*Varvaspis*) aff. *estonica* (Transition Beds). Internal mould of hypostoma. PU no. N 922. Gymninge. × 2,4. □H: *Megistaspis* (*Varvaspis*) *estonica*. (Zone of *M.* (*V.*) *estonica*). Hypostoma. PU no. N 430. Lanna. × 1,2. From Tjernvik 1956, Pl. 6:12. □I: Internal mould of pygidium. PU no. B 341. Finngrundet core: 58,60 m. × 1,2. □J—L: *Megistaspis* (*Megistaspis*) *lata* (Zone of *M.* (*M.*) *lata*). □J: Internal mould of fragmentary cranidium. The original of Törnquist, 1884. LO no. 625 T. Vikarbyn, Dalarna. × 0,9. □K: Fragmentary internal mould of small pygidium. Plastiform cast. PU no. B 365. Finngrundet core: 56,65 m. × 1,4. □L: Almost complete carapace. RM no. Ar. 16169.Berg, Östergötland. × 0,6.


A
B
C
D
G
E
H
F
I
J

portions of the occipital furrow are well defined; in internal moulds they may meet at the median line. The palpebral lobes are larger than those in *M.* (*M.*) *lata*, and are elevated considerably above the surface of the glabella. The posterior border furrows is missing. Libringenae and hypostoma are unknown. The pygidium is evenly rounded or slightly triangular in outline. The axis is long and narrow, occupying about five sixths of the sagittal pygidial length. The pleural fields do not reach the dorsal level of the axis. The posterolateral portion of the border is concave. Contrary to what pertains in *limbata*, the posterior end of the pygidium is not directed upwards.

OCCURRENCE. — In the lower half of the Zone of *Megistaspis* (*M.*) *lata* at Lanna.

Megistaspis (*Megistaspis*) n. sp. no. 2

The species differs from *Megistaspis* (*M.*) n. sp. no. 1 in its glabella being more or less indented at the anterior margin. The pygidial axis is shorter, occupying only about four fifths of the sagittal pygidial length. The concave postaxial border is consequently wider, and is directed slightly upwards. The pleural fields and the axis are of uniform height.

OCCURRENCE. — In the upper half of the Zone of *Megistaspis* (*M.*) *lata* at Lanna.

Megistaspis (*Megistaspis*) *simon* n. sp.
Figs. 7 C and 9 B—D

NAME. — The species in named for the hermit Simon of the Desert, because of the fact that specimens of larger trilobites are very rare in the lower limestone strata belonging to the Zone of *Megistaspis* (*M.*) *simon* at Lanna.

HOLOTYPE (here selected). — Internal mould of small cranidium collected by Dr. A. H. Westergård in 1927. S.G.U. no. Ac. 5.

TYPE STRATUM and TYPE LOCALITY. — Red limestone beds at Lundebodarna (Lunden) in northernmost Öland.

DIAGNOSIS. — Carapace large and broad. Good cranidia are very rare. They are broad; the transversal width in front of palpebral lobes being about three fourths or more of the sagittal length. Anterior branches of facial suture diverge strongly in front of eyes, then curve inwards and forwards, meeting at an angle of about 110°. Occipital furrow may be fully developed in internal moulds. Glabella comparatively short; the sagittal length with occipital ring being less than two thirds of the cranidial length. It is obtusely rounded or truncate anteriorly. Two pairs of apodemal pits are often found in the anterior portions of axial furrows, being most easily distinguishable in internal moulds. A pair of elongate alae are present. Posterior border furrow absent in dorsal surface of fixigenae. Palpebral lobes small; their exsagittal length being a little more than one sixths of the sagittal length of cranidium. They rise considerably above the surface of glabella. In the preglabellar field there is an elongate, shallow depression in median line. The genal spines are probably short and slender. Hypostoma unknown.

Pygidium broad; its greatest transversal width being about one and a third of the sagittal length. The posterior margin is evenly and broadly rounded; the posterior border more or less concave. The most conspicuous feature in the pygidium is the broadness of the axis which is at its middle about twice as wide as in *Megistaspis* (*M.*) *lata*. It rises slightly above the surface of the pleural fields.

DIMENSIONS. — Length of cranidium (sag.) 34,1 mm; width at posterior margin (tr.) about 37,5 mm; width at palpebral lobes (tr.) 30,0 mm; greatest width in front of eyes (tr.) 26,6 mm; length of glabella with occipital ring (sag.) 22,0 mm; greatest width of glabella (tr.) about 14,0 mm; length of pygidium (sag.) 53,0 mm; greatest width of pygidium (tr.) about 70,0 mm.

OCCURRENCE. — Zone of *Megistaspis* (*M.*) *simon*. Localities rich in the species are Skattungbyn in Dalarna and Lundebodarna in Öland.

Fig. 9 A: *Megistaspis* (*Megistaspis*) *lata*. (Zone of *M.* (*M.*) *lata*. Internal mould of pygidium. PU no. N 922. Lanna. × 1. □B—D: *Megistaspis* (*Megistaspis*) *simon* n. sp. (Zone of *M.* (*M.*) *simon*). □B: Internal mould of cranidium. Plastiform cast. S.G.U. no. Ac. 5. Lundebodarna (Lunden), Öland. Collected by A. H. Westergård. × 1,14. □C: Posterior aspect of the same cranidium. × 1,14. □D: Internal mould of pygidium. PU no. 923. Lanna (R 4,86 m). × 0,7. □E—F: *Megistaspis* (*Megistaspis*) *limbata*. (Zone of *M.* (*M.*) *limbata*). □E: Cephalon of a fragmentary carapace. PU no. N 924. Yxhult. Collected by J. Johansson. × 1,2. □F: Internal mould of fragmentary cranidium. PU no. N 925. Lanna (R 8,58 m). × 1,3. □G—H: *Megistaspis* (*Megistaspis*) *limbata* n. subsp. (Zone of *M.* (*M.*) *simon*). □G: Fragmentary internal mould of cranidium. PU no. B 388. Finngrundet core: 46,50 m. × 1,15. □H: Pygidium. PU no. B 390. Finngrundet core: 49,61 m. × 1. □I: *Asaphus lepidurus* (Zone of *Megistaspis* (*M.*) *limbata*). Fragmentary cranidium. PU no. B 435. Finngrundet core: 43,22 m. × 2,4. □J: *Asaphus* n. sp. (Zone of *Asaphus expansus*). Fragmentary cephalon. PU no. B 474. Finngrundet core: 36,60 m. × 1,2.

Megistaspis (Megistaspis) limbata (Boeck)
Figs. 7 E and 9 E—F

Pygidia abound. Good cranidia are very rare; they break on being extracted from the rock, because of their strong convexity.

LECTOTYPE. — See type species, p. 195.

DIAGNOSIS. — Cephalon strongly convex, subtriangular in outline. Preglabellar field sagittally long and concave. Concave posterolateral border of librigenae very narrow. Genal spines comparatively long, curving backwards and outwards. Cranidium always narrow in front of palpebral lobes; in the middle of the zone, the anterior branches of facial suture have become parallel to each others. In earlier specimens the sutures curve moderately outwards and the cranidium resembles those in the *Megistaspis* Limestone at Slemmestad in Norway. Sagittal length of glabella with occipital ring about two thirds of cranidial length. Occipital furrow fully developed in internal moulds and there is a small tubercle just in front of the furrow. A pair of elongate alae are present. Palpebral lobes small, situated close to posterior area of fixigenae; their exsagittal length being about one sixths of cranidial length. There is no posterior border furrow in the fixigenae. Posterior margin of hypostoma concave.

Pygidium subparabolic or slightly triangular in outline. Its sagittal length usually somewhat less than three fourths of the greatest pygidial width. Sagittal length of axis six sevenths or more of pygidial length. Postaxial border sagittally very short, and strongly concave; its posterior end directed upwards. Axis narrow. It shows thirteen segments and a triangular terminal portion in internal moulds. Seven pleural ribs are discernible.

OCCURRENCE. — Very frequent in the Zone of *Megistaspis (M.) limbata* in the mainland of Sweden; rarer in the island of Öland.

Megistaspis (Megistaspis) limbata (Boeck) n. subsp.
Figs. 7 D and 9 G—H

DIAGNOSIS. — Cranidium distinctly broader than in *Megistaspis (M.) limbata*; its greatest width in front of palpebral lobes being about three fourths of the sagittal cranidial length. Sagittal length of pygidium about three fourths of its greatest width. Sagittal length of pygidial axis only about five sixths or less of pygidial length. Posterior border accordingly longer (sag.) than in *limbata* itself, and less concave. Its posterior end is directed moderately upwards.

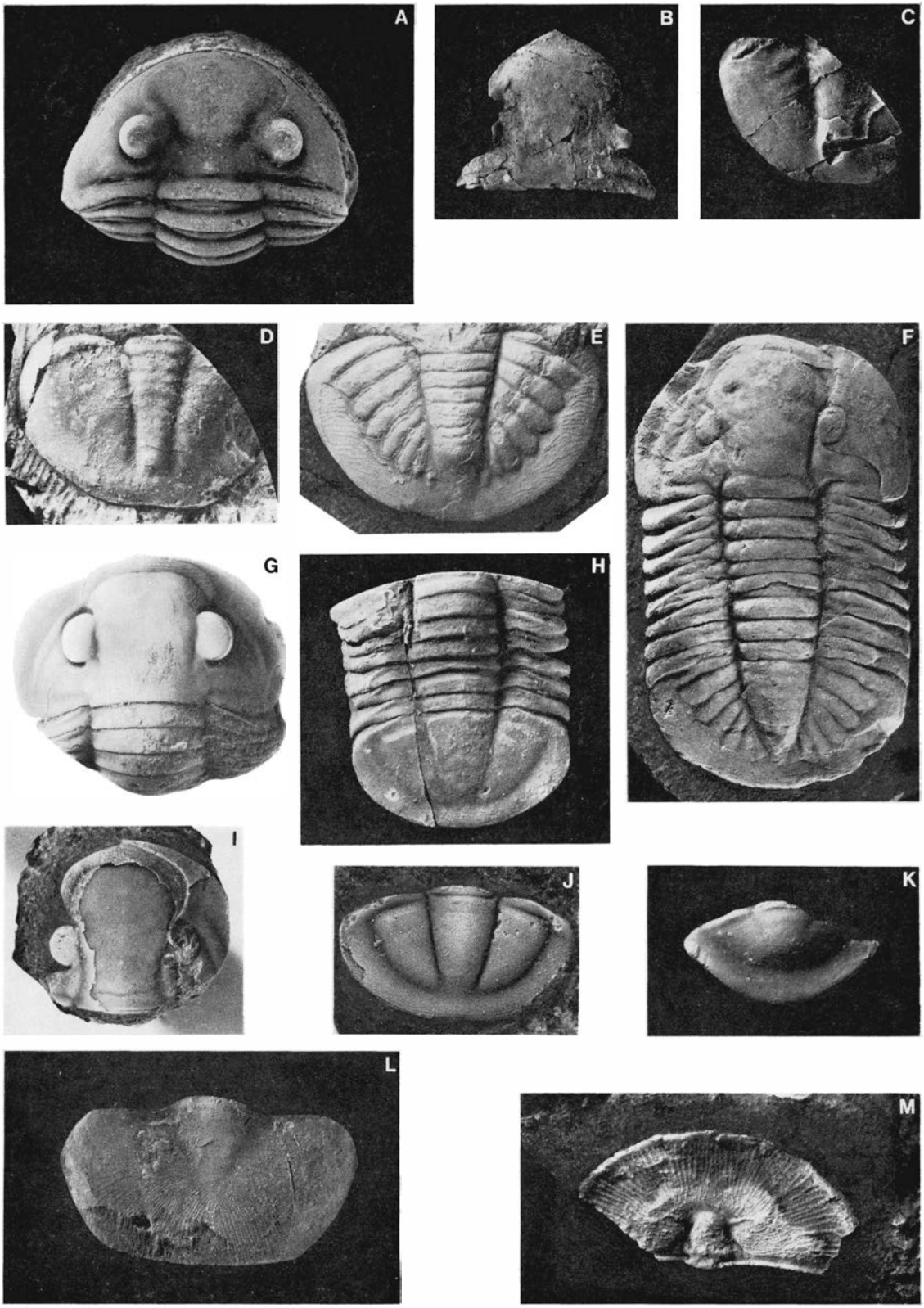
OCCURRENCE. — In the Zone of *Megistaspis (M.) simon* and the lowest part of the Zone of *Megistaspis (M.) limbata.* Intermediate forms between *limbata* and its new subspecies are known from Lanna. Such a form has been encountered in the Finngrundet core at 49,61 m. It is not marked in the diagram, text-fig. 4.

Genus *Niobe* Angelin, 1851
Figs. 10 E—F

The large and spectacular species of this genus seem to be scattered from Norway and France in the west to China in the east. The species are characterized by the shape of their pygidium. The pygidial doublure is always wide and the pleural ribs have a very peculiar form. These ribs in the Chinese species *Niobe yangtzeensis* were described by Lu (1975, p. 333) in the following words: "ribs thick, broadly rounded and bulging outwards at their distal ends, giving the line of demarcation between the central, elevated parts and the border a strongly undulating course" (cf. the pygidia of two species of *Niobe*, figs. 10 E—F in this paper). As regards the Scandinavian species, see Tjernvik (1956, text.fig. 36, p. 224), and Jaanusson (1959, p. 0350, text-fig. 259, 2b).

During the evolution in the genus, the glabella

Fig. 10 A: *Asaphus raniceps* (Zone of *A. expansus*). Cephalon and part of thorax. PU no. Ög 134. Borensberg. Collected by J. Johansson. × 1,5. □B: *Asaphus "raniceps"* (Zone of *A. "raniceps"*). Fragmentary cranidium. PU no. N 928. Lanna (R 15,07 m). × 0,55. □C: *Protoptychopyge prisca* (Zone of *Megistaspis (M.) lata*) .Fragment of pygidium. PU no. B 379. Finngrundet core: 54,94 m. × 1,2. □D: *Metaptychopyge truncata* (Zone of *Megistaspis (M.) simon*). Pygidium. PU no. B 399. Finngrundet core: 46,02 m. × 1,3. □E: *Niobe incerta* (Zone of *Megistaspis (Ekeraspis) armata*). Pygidium. PU no. Vg 113. Storeklev. From Tjernvik, 1956, Pl. 4:13. × 1,8. □F: *Niobe frontalis* (Zone of *Megistaspis (Megistaspidella gigas*). Carapace. PU no. Vg 861. Hällekis. Collected by J. Johansson. × 0,9. □G—H: *Niobella laeviceps* (Zone of *Asaphus expansus*). □G: Cephalon and part of thorax. RM no. Ar. 46001. Husbyfjöl. Collected by J. W. Dalman. From Tjernvik, 1956, Pl. 5:15. × 1,2. □H: Thorax and Pygidium. PU no. B 488. Finngrundet core: 37,33 m. × 1,4. □I—J: *Niobella lindstroemi* (Zone of *Megistapis (M.) simon*). □I: Fragmentary cephalon. PU no. N 926. Lanna (R 4,36 m). × 1,35. □J: Pygidium. PU no. N 927. Lanna (R 5,03 m). × 3,6. □K: *Pricyclopyge gallica* (Transition Beds). Fragmentary pygidium. PU no. B 330. Finngrundet core: 61,26 m. × 8. □L: *Illaenus aduncus* (Zone of *Asaphus "raniceps"*). Fragmentary pygidium .PU no. B 510. Finngrundet core: 25,85 m. × 1,2. □M: *Harpides* aff. *rugosus* (Zone of *Megistaspis (M.) simon*). Fragmentary cephalon. PU no. B 386. Finngrundet core: 47,41 m. × 4.


A
B
C
D
E
F
G
H
I
J
K
L
M

becomes wider in front of the eyes. In the hypostoma of early members, the posterior margin is rounded or straight. In later species a triangular, median noth has been developed in the margin. This noth is shallow in the species from the Hunneberg Substage; at hingher levels it becomes deeper and more prominent.

Niobe insignis Linnarsson occurs in the late Tremadocian; *Niobe incerta* and *N. emarginula* in the Hunneberg Substage. In the overlying Billingen Substage the genus is extremely rare. One fragment of a pygidium has been collected from the Transition Beds and another fragment by Johansson from the Zone of *Megistaspis* (*Varvaspis*) *estonica.* Not one single specimen has been encountered in the Lanna-Volkhov Stage.

The genus makes its next appearance in the uppermost Arenigian Zone of *Asaphus expansus.* It is a new species. Certainly, it was described by Brögger (1882), and by F. Schmidt (1901). However, Brögger identified it at first with the early *Niobe emarginula*, and later (Brögger, 1886) with the late *N. frontalis.* F. Schmidt (1901) referred it to the latter. Recently, Johansson found a couple of almost whole specimens of this form in the *expansus* zone of Närke.

The latest known species from Sweden is the genotype *Niobe frontalis* (Dalman) from the Llanvirnian. An almost complete carapace is illustrated here in fig. 10 F, for a comparison with the latest known species of *Niobella* Reed, that is, *Niobella laeviceps.* In addition, a pygidium of the early species, *Niobe incerta*, is figured.

Genus *Niobella* Reed, 1931

Figs. 10 G—J

The less spectacular species of *Niobella* have a regional and vertical distribution different from that of *Niobe.* It is also present in Great Britain and Newfoundland. *Niobe* is extremely scarce or absent in the limestones of the Swedish Billingen Substage and the Lanna-Volkhov Stage. *Niobella*, on the other hand, is frequent in all Swedish zones from the late Tremadocian to the uppermost Arenigian Zone of *Asaphus expansus.* Contrary to *Niobe*, it seems not to survive into the Llanvirnian of Scandinavia.

I distributed (Tjernvik, 1956) the Swedish species, which belong to the subfamily Niobinae Jaanusson (1959), among the genera *Niobe* and *Niobella.* My proposal was accepted by Jaanusson (1959).

DIAGNOSIS of *Niobella.* — The pygidial ribs are flattened. Their distal ends are smooth, and usually reach a line corresponding to the inner margin of the doublure. In a new species from the Zone of *Megistaspis* (*M.*) *limbata*, the pygidial pleural furrows are still rather well developed. In *Niobella lindstroemi* and *N. laeviceps* from the surrounding zones, the pleural fields are, on the contrary, quite smooth. The pygidial doublure is narrow in *Niobella obsoleta* (Linnarsson) from the late Tremadocian. In the overlying limestone strata, it becomes more and more broad.

From the Zone of *Megalaspides* (*M.*) *dalecarlicus* onwards, the anterior portion of the glabella in the *Niobella* spp. has abruptly been widened transversally just in front of the palpebral lobes (cf. Tjernvik, 1956, text-fig. 37 C, p. 229). The triangular notch in the posterior margin of the hypostoma undergoes an evolution parallel to that in *Niobe.*

Nileus Dalman, 1827

The many species and subspecies of the genus *Nileus* are very characteristic of the limestones belonging to the uppermost Tremadocian, the Latorp and Lanna-Volkhov Stages, as well as of the overlying strata. The genus has undergone a very complicated and probably dendriform evolution which has created all these different and readily recognizable trilobite forms. They are of great stratigraphical value.

Nileus limbatus Brögger is found in the Tremadocian Zone of *Apatokephalus serratus* and the two zones of the Hunneberg Substage. As mentioned in a preceding page, it has a rectangular glabella, and a very wide and deeply concave border.

The long-lived *Nileus exarmatus* Tjernvik turns up at the base of the Billingen Substage. The posterior and greater part of its glabella tapers forwards. The anterior margin of the cranidium is evenly rounded, or, as in the holotype, the facial sutures may meet in front at an extremely obtuse angle. The pygidium possesses a narrow, concave border. The terrace lines on the dorsal pygidial surface, which are of great taxonomic value in this genus, are rather few and moderately dense. They cover the anterolateral area of the pleural fields and of the border. The species is frequent in the Billingen Substage and most part of the Lanna-Volkhov Stage. The last specimens have been found in the Zone of *Megistaspis* (*M.*) *simon.*

Nileus n. subsp. (aff. *N. armadillo*) occurs in the Zone of *Megistaspis* (*M.*) *limbata* and the succeeding Zone of *Asaphus expansus.* It has a broad, almost quadratic glabella, and is probably an ancestor to the type species *N. armadillo* (Dalman) which is found at higher levels. The new subspecies differs in being much smaller than *armadillo.*

Nileus orbiculatus Tjernvik is restricted to the Transition Beds at the base of the Billingen Substage. Its glabella is semicircular in outline and its pygidium is quite convex. It is not an ancestral form of *N. orbiculatoides* Schrank.

The latter, *Nileus orbiculatoides*, seems to be a descendant of *N. exarmatus*. One form, called here *N. exarmatus orbiculatoides* n. sp. or subsp., turns up already in the Billingen Substage. Its cranidium differs from that of *N. exarmatus* in having a distinct median point or an obtuse tongue-like process in the anterior margin. The pygidium has the same narrow, concave border as in *N. exarmatus*. The ornamentation of terrace lines is, however, quite different. The lines are ramified and widely spaced, and cover at first only the lateral part of the pleural fields and of the border. During the succeeding evolution in the Zone of *Megistaspis* (*M.*) *lata*, they become scattered over the pygidium with exception of the axis, as is the case in *N. orbiculatoides*.

Nileus orbiculatoides is a very characteristic and valuable index fossil for the middle and greater part of the Zone of *Megistaspis* (*M.*) *simon*. The anterior margin of the cranidium possesses the same median point or tongue-like process as in the above species or subspecies. The pygidium has the same pattern of terrace lines, now fully developed. In the holotype, illustrated by Schrank (1972), one can discern a very slight concavity in the posterior area of the pygidium. In later specimens from Lanna, the convexity is strongly pronounced.

Quite another lineage of *Nileus* spp. or subspp. belongs to the group of *Nileus glazialis* (Schrank, 1972 and 1973). The pattern of terrace lines in *N. exarmatus*, *N. orbiculatoides* etc. is here replaced by an ornamentation consisting of extremely fine and dense grooves.

Schrank collected his specimens of *glazialis* from limestone boulders occurring in German glacial drift, deriving from Scandinavia or the Eastern Baltic region. He assumed that his species came from strata corresponding to the Swedish Zone of *Megistaspis* (*Varvaspis*) *estonica*. However, at Lanna the earliest member of the *glazialis* group makes its appearance at first in the lowest part of the Zone of *Megistaspis* (*M.*) *lata*, and then is distributed upwards to the lower strata of the Zone of *Asaphus expansus*.

This first member of the group is here called *Nileus glazialis* n. subsp. no. 1. Its cranidium resembles very much that of *N. exarmatus*. The glabella tapers moderately forwards in the same way. Small, scattered areas in this cranidium or all the cranidium may be covered with the fine grooves typical of the species. The pygidium has the same narrow, concave border as in *N. exarmatus*. The ornament of fine and dense grooves covers all the pleural fields, while the surface of the axis is smooth. Schrank believed that the latter fact was due to an obliteration of the grooves. This is, however, not the case; the many excellently preserved pygidia from Lanna posses a quite smooth axis.

Nileus glazialis glazialis (Schrank) turns up at the very top of the Zone of *Megistaspis* (*M.*) *lata*, and continues throughout the two overlying zones of the Lanna-Volkhov Stage. It also enters the uppermost Arenigian zone of *Asaphus expansus*. The cranidium differs from that of the above n. subsp. no. 1 in its glabella being semicircular in outline. The dorsal cranidial surface, at least in specimens from higher levels, may be finely punctate but lacking the grooves of the pygidium. The pygidial pleural fields are covered with the extremely fine and dense grooves of *glazialis*. Less dense ones enter at least the posterior area of the axis. The narrow, concave border is the same as in *N. exarmatus*.

Nileus glazialis n. subsp. or sp. no. 2 occurs in the zone of *Megistaspis* (*M.*) *limbata*, and has been found in the lower strata of the Zone of *Asaphus expansus*. The cranidium answers well to that of *N. glazialis glazialis*. The glabella is semicircular in outline and its dorsal surface is finely punctate. The pygidial surface has the usual pattern of very fine and dense grooves. The concave border, which is present in the pygidium of *N. glazialis glazialis*, has disappeared and the pygidium is fully convex. As mentioned above (p. 195), the form seems to be closely related to *N. glazialis costatus* Fortey (1975, p. 41, pl. 10; pl. 16, fig. 8), from the Olenidsletta Member (middle Arenig) of Spitsbergen.

The many species and subspecies of *Nileus* in the Lower Ordovician of Sweden are good index fossils. They are in urgent need of description.

Illustrations

A great number of the fossils found in the core are readily recognized and determined, although most of them are damaged, corroded etc., and very few of them are suitable for illustration.

REFERENCES

Angelin, N. P., 1851: Palaeontologia Svecica. *I*, 24 pp. — Reprinted in Palaeontologia Scandinavica.

Angelin, N. P., 1854: Palaeontologia Scandinavica. P. I, 96 pp. *Crustacea Formationis Transitionis*. Holmiae.

Bohlin, B., 1949: The Asaphus Limestone of Northernmost Öland. *Bull. Geol. Inst. Upsala. 33*, 529—570.

Bohlin, B., 1960: Trilobites of the genus *Megistaspis* from the Vaginatum Limestone of Scandinavia. *Bull. Geol. Inst. Uppsala. 38*, 155—205.

Bohlin, B. & Jaanusson, V., 1955: The lower Ordovician limestones between the *Ceratopyge* shale and the *Platyurus* limestone of Böda Hamn. *Bull. Geol. Inst. Uppsala. 35*, 111—173.

Brögger, W. C., 1882: Die silurischen Etagen 2 und 3 im Kristianiagebiet und auf Eker. *Universitätsprogramm*, 376 pp. Kristiania.

Brögger, W. C., 1886: Über die Ausbildung des Hypostomes bei einigen skandinavischen Asaphiden. *Sver. Geol. Undersökn. Ser. C, 82*, 78 pp.

Bruton, D. L., 1968: The trilobite genus *Panderia* from the Ordovician of Scandinavia and the Baltic areas. *Norsk Geol. Tidskr. 46*, 53 pp.

Bulman, O. M. B. & Rushton, A. W. A., 1973: Tremadoc faunas from boreholes in Central England. *Bull. Geol. Surv. Gr. Britain. 43*, 40 pp.

Dalman, J. W., 1827: Om Palaeaderna eller de så kallade Trilobiterna. *K. Vet.-Akad. Handl.*, 109 pp.

Dean, W. T., 1973: The lower Palaeozoic stratigraphy and faunas of the Taurus Mountains near Beysehir, Turkey. III. The trilobites of the Sobova Formation (Lower Ordovician). *Bull. British Mus. (N.H.). 24*, 279—348.

Erdtmann, B.-D., 1965: Outline stratigraphy of graptolite-bearing 3b (Lower Ordovician) strata in the Oslo Region, Norway. *Norsk Geol. Tidskr. 45*, 481—547.

Fortey, R. A., 1974: A new pelagic trilobite from the Ordovician of Spitsbergen, Ireland, and Utah. *Palaeont. Ass.*, 111—124.

Fortey, R. A., 1975: The Ordovician trilobites of Spitsbergen II. Asaphidae, Nileidae, Raphiophoridae, and Telephinidae of the Valhallfonna Formation. *Norsk Polarinst. 162*, 207 pp.

Henningsmoen, G., 1959: Rare Tremadocian trilobites from Norway. *Norsk Geol. Tidskr. 39*, 153—174.

Holm, G., 1881: Über einige Trilobiten aus dem Phyllograptusschiefer Dalecarliens. *Bih. K. Sven. Vet.-Akad. Handl. 6:9*, 16 pp.

Jaanusson, V. und Mutvei, H., 1951: Ein Profil durch den Vaginatum-Kalkstein im Siljan-Gebiet, Dalarna. *Geol. För. Stockholm Förhand. 73*, 629—636.

Jaanusson, V., 1956: Untersuchungen über baltoskandische Asaphiden. III. Über die Gattungen *Megistaspis* n. nom. und *Homalopyge* n. gen. *Bull. Geol. Inst. Uppsala. 36*, 59—78.

Jaanusson, V., 1957: Unterordovizische illaeniden aus Skandinavien. *Bull. Geol. Inst. Uppsala. 37*, 79—166.

Jaanusson, V., 1959: Treatise of Invertebrate Paleontology (ed. R. C. Moore) O, Arthropoda 1, 560 pp. *Univ. Kansas Press.*

Jaanusson, V., 1960: Graptoloids from the Ontikan and Viruan (Ordov.) limestones of Estonia and Sweden. *Bull. Geol. Inst. Uppsala. 38*, 289—366.

Jaanusson, V., 1975: Evolutionary process leading to the trilobite suborder Phacopina. *Fossils ans Strata. 4*, 209—218. Oslo.

Kohut, J. J., 1972: Conodont biostratigraphy of the Lower Ordovician Orthoceras and Stein limestone (3c), Norway. *Norsk Geol. Tidskr. 52*, 427—445.

Lindström, G., 1901: Researches on the visual organs of the trilobites. *K. Svenska Vet.-Akad. Handl. 34:8*, 84 pp.

Lindström, M., 1957: The Ordovician conodont faunas found with zonal graptolites. *Geol. För. Stockholm Förh. 79*, 161—178.

Lu, Y.-H., 1975: Ordovician trilobite faunas of Central and Southwestern China. *The Science Press*, 463 pp. Peking.

Moberg, J. C., 1890: Anteckningar om Ölands ortocerkalk. *Sver. Geol. Undersökn. Ser. C. 109*, 22 pp.

Moberg, J. C. & Segerberg, C. O., 1906: Bidrag till kännedomen om Ceratopygeregionen. *Lunds Univ. Årsskr. N.F. 2:2:7*, 115 pp.

Männil, R. M. [Мянниль, Р. М.] 1966: История развитич балтийского бассейна в ордовике (History of the evolution of the Baltic basin in the Ordovician, 200 pp.) Валгус, Таллин.

Poulsen, V., 1965: An early Ordovician trilobite fauna from Bornholm. *Medd. Dansk Geol. For. 16:1*, 49—113.

Regnéll, G., 1942: Stratigraphical and paleontological remarks on the Lower Ordovician of Central and Northern Öland. *Lunds Geol. Inst. 99*, 17 pp.

Rosova, A. W. [Розова, А. В.] (ed.) 1975: Описание палеонтогических объектов с применением латинских термиксов. (Description of palaeontological objects with the use of Latin terminology, 244 pp.) Новосибирск.

Schmidt, F., 1901: Revision der ostbaltischen Trilobiten. ten. V:2. *Mém. l'Acad. Imp. Sci. St.-Pétersbourg. 8: 12:8*, 113 pp.

Schmidt, F., 1906: Revision der ostbaltischen Trilobiten. V:4. *Mém. l'Acad. Imp. Sci. St.-Pétersbourg. 8:19:10*, 62 pp.

Schrank, E., 1972: *Nileus*-Arten (Trilobita) aus Geschieben des Tremadoc bis tieferen Caradoc. *Ber. deutsch. Ges. geol. Wiss. A. 17:3*, 351—375. Berlin.

Skjeseth, S., 1952: On the Lower Didymograptus Zone (3b) at Ringsaker, and contemporaneous deposits in Scandinavia. *Norsk Geol. Tidskr. 30*, 137—182.

Størmer, L., 1941: Early descriptions of Norwegian trilobites. *Norsk Geol. Tidskr. 20*, 113—151.

Thorslund, P. & Jaanusson, V., Norden 1960: The Cambrian, Ordovician, and Silurian in Västergötland, Närke, Dalarna, and Jämtland, Central Sweden. Guide to excursions. *Int. Geol. Congress. Geol. Surv. Sweden*, 51 pp.

Tjernvik, T. E., 1956: On the early Ordovician of Sweden. Stratigraphy and fauna. *Bull. Geol. Inst. Uppsala. 36*, 107—284.

Tjernvik, T. E., 1958: The Tremadocian beds at Flagabro in south-eastern Scania. *Geol. För. Stockholm Förh. 80*, 259—276.

Törnquist, S. L., 1884: Undersökningar öfver Siljansområdets trilobitfauna. *Sver. Geol. Undersökn. Ser. C. 66*, 101 pp.

Westergård, A. H., 1940: Nya djupborrningar genom äldsta ordovicium och kambrium i Östergötland och Närke. (New deep borings through the lowest Ordovician and Cambrian of Östergötland and Närke. Sweden.) *Sver. Geol. Undersökn. Ser. C. 437*, 72 pp.

Whittington, H. B., 1950: Swedish Lower Ordovician Harpidae and the genus *Harpides*. *Geol. För. Stockholm Förh. 72*, 301—306.

Whittington, H. B., 1965: Trilobites of the Ordovician Table Head Formation, Western Newfoundland. *Bull. Mus. Comp. Zool. Harvard. 132,4*, 277—441. Cambridge. Mass.

Wiman, C., 1905: Ein Shumardiaschiefer bei Lanna in Nerike. *Arkiv f. Zool.* 2:11, 20 pp. Uppsala.

Printed by Ekenäs Tryckeri Ab, Ekenäs, Finland February, 1980.

Addendum to Bulletin of the Geological Institutions of the University of Uppsala, N.S., Vol. 8, 1980, pp. 173–204.

"Description of the upper portion of the drill-core from Finngrundet in the South Bothnian Bay" by Torsten E. Tjernvik and Jan V. Johansson forms Part II of "Geology of the southern Bothnian Sea", the first part of which appears in this volume on pages 35—62, under the authorship of Per Thorslund and Stefan Axberg.